A Gambler's Guide to Free Will in a Deterministic Universe, Part 2

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Two Plus Two Magazine, Vol. 16, No. 8

Gamblers seek randomness – human brains are attuned to celebrate the uncertainty. Poker is perhaps humankind's most influential game, driving today's artificial intelligence and informing the game theory of nuclear existential threat. What makes poker compelling is its sublime mix of gamble and skill driven by incomplete information. Yet the laws of physics give us a deterministic universe where incomplete information leads to what is traditionally called randomness but is perhaps preordained. The apparent uncertainty is the product of our ignorance. In part 1, the consequences of this situation from a gamblers point of view in a purely classical mechanical (CM) universe were explored. Here, I will expand on that and explore how a quantum mechanical (QM) universe with a different type of true randomness, i.e. that which is demonstrably not a product of incomplete information, changes the situation.

Let's start with some facts from my point of view. We don't know very much about the fundamental nature of existence in the universe. Some of the known or unknown unknowns about the universe are likely essential in sorting out randomness, consciousness, and free will. For example, the nature of time itself is poorly understood. Is the universe infinite or finite? Is our universe part of a larger finite or possibly infinite superstructure? If it is infinite, there are still many or infinitely many ways to construct infinities, which is relevant? How are the initial conditions of the universe set? Is it even rational to consider the time evolution of the universe, or would a higher dimensional picture change this notion? If the universe evolves via rules like the time dependent Schrödinger equation: 1) are there stochastic contributions? 2) is it a differential of finite precession difference equation evolution?

One can make guesses at some of these things. For example, thought and empirical explorations of black hole thermodynamics, the cosmic horizon, and the residual big bang black body radiation may shed some light on open questions. Still, big uncertain issues arise. What does it even mean to have parts of the universe become uncoupled from our reality? These musings are to point out that humanity has little insight into the big questions and humans have made so much progress that our ignorance is easy to overlook. For goodness sake, we don't even know what 85% of the gravitationally active matter of the universe is made up of (dark matter) or what is pushing the universe to rapidly expand to a heat death (dark energy). Giving them names is a start one supposes. Nonetheless, we do know a few things and can consider the consequences. Theories of known phenomena must be consistent with established rules of the game or conversely, propose new ones that reduce to the old ones where appropriate.

It is useful to frame many of these kinds of questions in terms of information, which has a deep connection to entropy via a simple formula called the Gibbs entropy in thermodynamics that is isomorphic to the Shannon entropy in information theory. Suffice it to say there are ways to quantitate information and it is becoming a unifying language of computation and physical theory. I have started to think of information as a quantity relative related to an observer, like velocity. Moving at a constant velocity is the same as standing still unless measured relative to another object. In some contexts, information has a special meaning relative to what is knowable in a system. An individual has information relative to the observable universe as an example. A particular individual / computing device will have a limited information and learning capacity. Individuals are incomplete information machines that modify themselves in response to "external" stimuli and measure and react in a modified fashion. They learn. Learning changes the state of the brain and it thereafter acts as modified.

Note, these kinds of models strictly depend on being able to reduce the universe into a system, e.g. a human, and the environment, e.g. everything else substantially connected to the human. In CM, this can usually be done to an arbitrary precision while in QM this construction is fraught with complexity and difficulties. Even a single quantum mechanical atom connected to something behaving clearly classically leads to seeming contradictions. Schrödinger's cat paradox is a famous example, but less fanciful realizations exist in real devices. Yet, considering either QM or CM, the subsystem has limited capacity to organize, predict, and store information. One can imagine universes that are more or less predictable. The one we observe appears to evolve according to easily stateable differential equations in all instances we can test and measure. Specifically, the time evolution is governed by the dependent Schrödinger equation that reduces to Newtonian CM in many situations. But even knowing the rules of the game, we have a limited capacity to simulate its outcomes.

Reconsider a purely CM evolving universe. One can imagine an omniscient external observer of a classical, purely, deterministic system like a CM universe. But any subsystem of that universe, e.g. an observer that's a part of that universe, will have severe limitations on what they can know even though the system is evolving deterministically. Some classical universes will have, based on the initial conditions, more of fewer things predictable based on inference from observed trajectories and knowing that things evolve in a Newtonian fashion. Further, can we even ever know that this is happening with certainty even if it were the case? There are limits on the certainty we can have in even knowing the rules of the game.

Nonetheless, within the known universe it appears to be a game of incomplete information. This is in fact how statistical thermodynamics, perhaps humankind's most powerful extant theory, is best formulated; physical theory connects the laws of motion to the observed thermodynamics of everyday life. First, we have certain knowns or constraints like conservation of energy which is an apparent law nature and a property of both CM and QM time evolution. Then if the environment has a given temperature and pressure that we observe, everything else that can happen, consistent the equations of motion, is assumed to happen with equally likely probability. This set of assumptions can explain most observed phenomena in terms of the fundamental laws of nature. It explains why every glass of water at room temperature and atmospheric pressure appears the same with a density of 1g/cc and identical average structure. The detailed dynamics of each drop of water is unique but, given our ignorance of these details, they all quench our thirst equally well. The deterministic dynamics of atoms and molecules demonstrate this flavor of random behavior. In this case, our incomplete information allows us to usefully average over our ignorance and form an elegant and powerful description of matter. Statistical thermodynamics explains phenomena as diverse as black hole radiance and evaporation, the freezing and thawing of liquids and the nature of matter from the surface of a star to the inside of a planet. Thus, randomness and ignorance can be a double-edged sword, sometimes complicating other times simplifying our understanding.

One question is can randomness be extracted from even CM determinism? The answer depends on the definition of randomness. Perhaps humans need different words for randomness, like Eskimo's for snow. Consider, it is possible that given the chaotic nature of classical trajectories, random numbers can be extracted from deterministic processes. By that I mean random numbers that can't be calculated even knowing they resulted from a known deterministic process; the resulting string of numbers will have the desired spectral properties associated with an a priori distribution function. For example, simple random numbers might be a string of integers between 1–10 generated without a bias for any one number. Thus, from determinism come random outcomes. One might even associate a freedom of behavior or will to the system that one knows is behaving deterministically. Mountain weather has a mind of its own. This is as true for the weather and humans and for essentially the same reasons.

I personally use radom.org for gambling purposes on a regular basis, where random numbers are generated from atmospheric noise. These numbers are not random to an omniscient external observer with a knowledge of mechanics, but they are perfectly random to us. The computation to predict them is not extant and the information to retrodict them is quickly lost. Most random numbers used in computation like online poker "shuffling" are strings of predetermined numbers generated from a deterministic process with equal card ordering probabilities in a given deck, i.e. given all possible decks each one is equally likely to be chosen.

Thus, human behavior can be predictable in principal and perhaps sometimes in practice yet have both random and free will qualities. Determinism is not destiny. QM adds some spice to the mixture in that the randomness associated with the theory is of a slightly different flavor. I discussed some of this in Poker as War: Reducible & Quantum Games, Randomness and Free Will? If in QM one makes the natural decomposition of a physical process into system and environment, randomness takes a prominent position in understanding the outcome. Measuring the position of an electron in an atom will yield a probabilistic outcome distinct from those above. It is demonstrable that the result is random, and no improvement of our incomplete information will result in a better-defined specific result, only a set of outcomes each associated with a definite probability. Many experiments have proven this probing Bell's profound theorem that can be summarized as "God does play dice." To point, sometimes we find the identically prepared electron "there" when we look and others we won't. We can predict the probability of the outcome exactly but never the result definitely. For example, we might be able to say I can find the electron within 1.0 nanometer of a proton 95% of the times I measure, but I can never know the outcome of a particular measurement. Our experience in the universe appears to be built on a foundation of randomness.

In poker, this would be the equivalent of the not being able to know the identity of the river, or final community card, until it is turned over. We could only know that it is one of 47 possible choices, but no measurement of a quantum deck could reduce that uncertainty. In a normal CM deck of cards, we could measure the card and cheat using a card reader as an example. The QM deck would be made to collapse to the single card upon measurement. These kinds of considerations are being used to try and use QM phenomena to construct encryption mechanisms that would reveal any attempts to tamper in the communication by producing such a collapse. The point is CM outcomes are pre-determined and the randomness is due to our ignorance via incomplete information. Better measurements can yield more information. QM outcomes are probabilistic and complete knowledge of the situation yields only the probability of an outcome.

QM adds a new form of randomness to the ocean of ignorance in which we find ourselves. People, notably Roger Penrose, have reasonably speculated that QM phenomena of this type might play an essential role in brain function and consciousness. This would introduce an essential unpredictability in the experience in an individual's universe. This leads to a huge possible number of outcomes with the vast majority never being explored. In Many Worlds quantum mechanics, they would all be explored but the individual experience would still be a single path through the probabilistic maze of outcomes. From one perspective, the coupling of brain behavior to QM phenomena is like making the brain a quantum random number generator with truly unpredictable outcomes. Notably, the brain itself has no bearing in steering the QM part of the outcomes any more than the electron picks where it is when we measure its location. Brain evolution can become highly stochastic but no freer.

Clearly, plenty is unknown about the nature of free will and consciousness or else we would know how to build thinking machines or perhaps even find that we can't do so. Nonetheless, there are severe constraints on what the nature of free will is, based on well tested physical theory. Whether thinking machines are a continuum of sophistication, or there is a quantum leap to consciousness, the laws governing their performance should follow CM and QM determinism with the associated random elements already discussed. Some determinism is predictable, and some is predictably undetermined.

Imagine a poker player making a decision at the table. Perhaps they adapt a balanced GTO-like strategy that bases decision precisely on the game state: the cards they hold, the community cards, the stack sizes of opponents and the betting to that point. Another opponent may tap into other human algorithms and assess the mindset of the opponent weighing their options. Yet another person may just do what comes naturally to them in the spot given their informed competence. In all these cases, no free will was exercised although the nature of the neuro-computation is quite different in each case. Coming into the game, each brain was in a state influenced by prior decisions. Humans are flexible learning and information processing machines. Their past behavior and experiences inform their future actions that are unpredictable to even them. Although here, unlike the investing caveat, past performance is usually indicative of future results. We reveal ourselves to ourselves and become a new self.

While someone committed to a GTO strategy may be easier to predict, their emotional state might change their approach implicitly or explicitly at any moment. They are trying to emulate a GTO robot but using a temperamental computing device known as the brain. A useful model for free will is the brain is in a state informed by past information. Its systems and algorithms interact / compete, and the person ultimately acts as the laws of nature inevitably push time forward. While an omniscient external observer may be able to predict either the detailed outcome, or if explicitly coupled to QM events, a range of probabilistic outcomes (perhaps an enormous range or a statistically averaged highly likely one?), none of these is any way controlled by the decision maker themselves. Ultimately, it seems the entire universe evolves according to deterministic laws with random elements -- at least as they appear to a rational observer that is a subset of the universe. It is an open question to what extent things are predictable, even if it seems likely that the best one can do is predict a likely distribution of outcomes. The success of thermodynamics suggests that the overwhelming number of possible outcomes might lead to emergent simplicity. While each glass of water has an astronomically high number of possible states, we only observe a consistent highly likely subset of them.

In sum, QM has foundational randomness and CM has incomplete information-based randomness as a feature. Thus, QM has both kinds of randomness as CM is a subset of QM. An example of using randomness in decisions is generating a random number in game theory to randomize one's actions in mixed situations to balance equivalent expected value situations. Another is flipping a coin for stacks when one has had enough punishment from the Universe at the end of a long losing poker session. These events are distinct in whether choosing the random number is QM or CM in nature. This is a very unusual feature of our universe. Does our perception of the universe, free will and consciousness require randomness and / or QM? This is a great unresolved question.

The point of the articles was that a theory of consciousness needs to be consistent with the deterministic albeit stochastic laws of nature. I hope it is also clear that that is not a severe limitation. Further, the colloquial definitions of free will do violate this constraint and imply super-natural manipulations including interventions perhaps non-local in time to guide the universe on a new path based on cognitive function. Such theories also suffer from a logical problem that any supernatural intervention extends the natural system and then begs a theory of the composite universe. The universe is spooky but doesn't need that additional dimension. You are more likely to have a free lunch than a free will.

Brian Space is a scientist and professor seeking people to play Quantum Statistical Mechanics for money. He plays poker but is no old man coffee. Remember the GTO strategy ignores that of the other players – you really want to play like that? His poker articles are available on his web site: http://drbrian.space/poker.html

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