To What Extent Does Quantum Mechanics Impact Free Will?

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1. Introduction

"I don't quite understand what it is that compels me to type this letter. Perhaps it is to leave some vague reason for the actions I have recently performed. I don't really understand myself these days. I am supposed to be an average, reasonable and intelligent young man. However, lately (I can't recall when it started) I have been a victim of many unusual and irrational thoughts… After my death, I wish that an autopsy would be performed on me to see if there is any visible physical disorder. I have had some tremendous headaches in the past and have consumed two large bottles of Excedrin in the past three months."[1]

Charles Whitman wrote what would effectively become his suicide note the night before he committed the mass murders at the University of Texas tower shooting on August 1, 1966. The excerpt above is from the note. Whitman would kill 14 and wound 31 others the next day before being shot and killed by police. An autopsy showed that Whitman indeed had a tumor in the white matter above his amygdala, a region of the brain associated with emotion regulation and aggression.[2]

Is Whitman an evil person or a victim of biology? If we had a perfect account of what was happening at every synapse in Whitman's brain, and we learned the difference between what creates a Whitman and not Gandhi, would we consider him unlucky? These are hard questions because they touch on free will, a phrase that has emerged over the past two millennia as the "canonical designator for a significant kind of control over one's actions."[3] In talking about free will, we have to consider questions about causation, laws of nature, time, the relationship of causal and reasons-based explanations, the nature of motivation, and right and wrong. Even if we get past those questions, there remains the purely empirical question of whether we have free will, and to what extent we have it.

Something we have done as a species quite well is to use logic, and by extension, math and physics, to get closer to answers to hard questions. Newtonian mechanics helped us understand the motion of celestial bodies. General relativity explained the nature of gravity. These are examples of classical physics. Classical physics operates under the assumption that the universe is a well-ordered, predictable system. This leaves little room for an indeterminate idea like free will. But quantum mechanics introduces inherent randomness and suggests that certain events at the microscopic level are fundamentally unpredictable.[4] It breaks the strict causal chain of events implied by classical physics. This indeterminism leaves open a space where not all future events are predetermined, allowing for free will to operate independently of deterministic physical laws. As a curious species, this is an interesting pond to swim in.

In this paper, I will explain how we should think about free will in the context of physics. The discussion will be grounded in examples of emergence, a phenomenon where higher-level properties arise from the interactions of lower-level components in a system. This paper will start with two examples from the classical world, then focus on free will as an emergent property, and finally discuss the philosophical implications of these findings. All this to make the claim that **whether or not one believes in free will depends on how much influence they think quantum mechanics has on the decision-making processes within the brain**.

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[1] "Charles Whitman's Suicide Note," Library of Babel, July 31, 1996, https://tayiabr.wordpress.com/2017/08/26/charles-whitmans-suicide-note/.
[2] "Charles Whitman," Wikipedia, https://en.wikipedia.org/wiki/Charles_Whitman.
[3] "Free Will," Stanford Encyclopedia of Philosophy, January 7, 2002. https://plato.stanford.edu/entries/freewill.
[4] "Quantum Mechanics," Stanford Encyclopedia of Philosophy, November 29, 2000. https://plato.stanford.edu/entries/qm.

2. Emergence in Thermodynamics

Emergence is the phenomenon where larger entities and patterns arise through interactions among smaller entities that themselves do not exhibit such properties. In other words, emergent properties are those that are not present in the individual components but manifest when these components interact at a system level. Both physicists and philosophers have thoughts on emergence. Karen Barad, a physicist, has an idea called agential realism, which states that emergence results through dynamic interactions among parts, where the relationships and exchanges between them create new, higher-level properties. This process is complex and non-linear, involving both material and discursive elements that shape reality and knowledge.[5] Henri Bergson, a French philosopher, highlights the continuous flow of time and the ongoing creative process that leads to the diverse forms of life we see.[6]

How does this manifest in the real world? One example is thermodynamics. At the fundamental level, thermodynamics is grounded in the behavior of atoms and molecules. But when we observe large collections of these particles, we see emergent properties that are not evident at the microscopic level. Temperature, pressure, and viscosity are examples of such properties. These macroscopic quantities arise from the collective behavior of many particles and can be effectively described without detailed knowledge of each particle's state. The waiter need not know the state of the universe to know what a customer wants to order for dinner; they can just ask. It is important to note that emergent properties in thermodynamics are described deterministically and can be predicted from the deterministic behavior of atoms and molecules, illustrating the concept of weak emergence.

To be clear, even though emergent properties may be complex, weakly emergent properties can be predicted or simulated based on the underlying micro-level laws, while strongly emergent properties cannot be predicted or derived from the underlying micro-level laws, no matter how much we know about the microscopic details. The examples listed earlier are weakly emergent properties. Some think that consciousness is a strongly emergent property. More on that later. Regardless, the transition from the microscopic to the macroscopic is a cornerstone of thermodynamics, showing how complex behaviors can emerge from simple, fundamental interactions while still being rooted in the deterministic laws governing the behavior of individual particles.

Zooming in, statistical mechanics provides the microscopic foundation for thermodynamics by using statistics to link the behavior of individual particles to the macroscopic properties described by thermodynamic laws. It further proves this concept by providing the bridge between microscopic interactions and macroscopic properties. The distribution of particle velocities in a gas, described by the Maxwell-Boltzmann distribution, leads to the emergent property of temperature.[7] Pressure arises from the collective impact of countless molecular collisions with the walls of a container. In statistical mechanics, emergence is characterized by the transition from individual particle behavior to collective phenomena that can be described by statistical averages and distributions. This framework allows us to derive macroscopic thermodynamic laws from the underlying microscopic dynamics. The ensemble approach in statistical mechanics treats large numbers of particles as collections, where the exact state of each particle is less important than the overall statistical properties of the system.

Emergence in thermodynamics illustrates how higher-level properties and behaviors can arise from the interactions of simpler elements, with statistical mechanics providing the theoretical foundation for

[5] Karen Barad, Meeting the Universe Halfway, chapter: "The Science of Ethics and Mattering", July 11, 2007.
[6] Henri Bergson, Creative Evolution (1907).
[7] "Identity and Individuality in Quantum Theory," Stanford Encyclopedia of Philosophy, February 15, 2000. https://plato.stanford.edu/entries/qt-idind.

understanding this transition. This interplay between the microscopic and macroscopic realms demonstrates the power of emergent properties and highlights the importance of statistical methods in uncovering the principles governing complex systems.[8]

3. Computing and Weak Emergence

Another example is computing. At the fundamental level, computing is based on transistors, logic gates, and binary code. These basic elements interact to give rise to emergent properties like software and artificial intelligence (AI). It can be agreed that there is nothing mysterious about AI, since the underlying components are well understood. As such, here see agential realism in action - emphasizing that the behaviors and capabilities of things like AI emerge from the complex interplay of their underlying components. These properties can be predicted or simulated based on the underlying micro-level laws, demonstrating the principle of weak emergence. The components at the micro-level follow deterministic rules, their interactions lead to the emergence of complex, higher-level functionalities that define modern computing systems. That being said, we can see that the fundamental components and the emergent properties in computing are deterministic. Emergent properties in computing, much like in thermodynamics, arise from simple, deterministic interactions at a fundamental level.

4. Conway's Game of Life

Before we move on to the mind, let's make a quick pit stop at the Game of Life. Conway's Game of Life provides a compelling illustration of how simple, deterministic rules can give rise to complex, emergent behaviors. In the Game of Life, a cellular automaton evolves based on a set of straightforward rules governing the birth, survival, and death of cells.

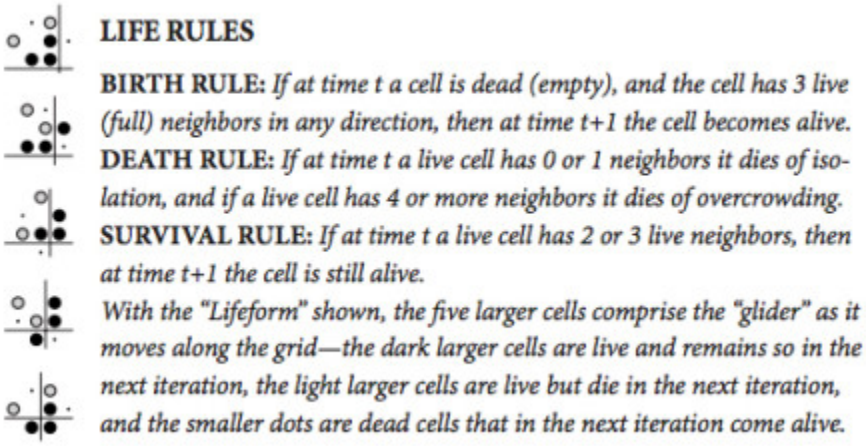

Figure 1: Rules to The Game of Life.[9]

[8] "Free Will is as Real as Baseball," Preposterous Universe, July 13, 2011, https://www.preposterousuniverse.com/blog/2011/07/13/free-will-is-as-real-as-baseball.
[9] Siobhan Roberts, "A Life in Games: The Playful Genius of John Conway," Wired, September 5, 2015, https://www.wired.com/2015/09/life-games-playful-genius-john-conway.

Most of the time you will get something random like this.

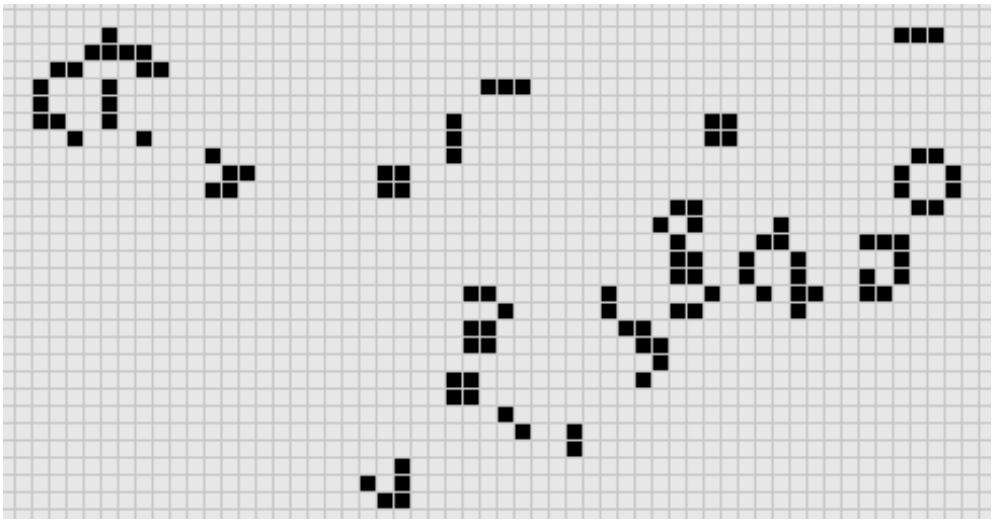

Figure 2: An Example of a Cellular Automaton.[10]

But sometimes the interactions among cells lead to the "emergence" of intricate patterns and structures, such as gliders, oscillators, and even self-replicating configurations.

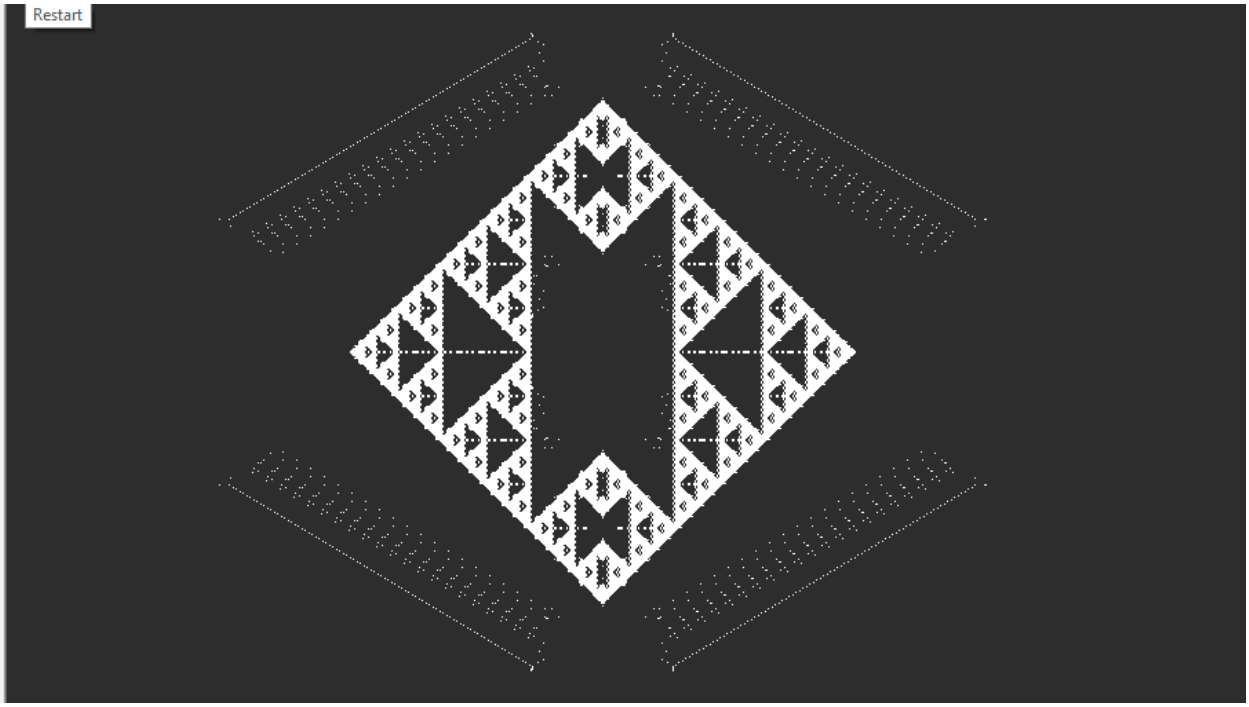

Figure 3: Fragment of a Typical Evolution for large n.[11]

[10] Chris Lipa, "Conway's Game of Life," Cornell Math Explorers' Club, https://pi.math.cornell.edu/~lipa/mec/lesson6.html.
[11] "Vanishing Line on Conway's Game of Life," MathOverflow, thread started December 14, 2017, https://mathoverflow.net/questions/288423/vanishing-line-on-conways-game-of-life.

This emergence mirrors the phenomena we see in thermodynamics and computing. In thermodynamics, the collective behavior of particles gives rise to macroscopic properties like temperature and pressure, while in computing, the interactions among transistors and logic gates enable the emergence of software and artificial intelligence. The Game of Life demonstrates that complex, higher-level behaviors can emerge from simple, deterministic rules, showcasing the principle of weak emergence. It provides a powerful analogy for understanding how emergent properties in various domains can arise from fundamental, deterministic interactions.

5. The Mind and Quantum Mechanics

When it comes to the mind, addressing emergent properties becomes more complicated. The mind's emergent properties, such as consciousness and free will, are influenced by a complex interplay of both deterministic and indeterministic processes at the fundamental level. Deterministic processes include things in neuroscience, and dynamic networks, or what we call chaos theory. But the indeterministic process of quantum mechanics is also involved.

Neuroscience reveals neurons firing and synapses transmitting signals in a predictable manner based on the brain's structure and previous states.[12] One interesting example is the "hungry judge effect." Studies have shown that judges are more likely to issue harsher sentences before they have had lunch, when they are hungry, and more lenient sentences after eating.[13] This phenomenon actually became the basis for the popular Snickers commercials, 'You're not you when you're hungry.' It is an intriguing yet alarming fact. And chaos theory further highlights the intricate yet deterministic dynamics of neural networks, where small changes in initial conditions can lead to vastly different outcomes. But the introduction of quantum mechanics adds an element of indeterminism to the mix. Quantum phenomena such as superposition and entanglement have been proposed to play a role in brain function, potentially influencing neural activity and decision-making processes in a fundamentally unpredictable way.[14]

The interplay between these deterministic and indeterministic processes at the fundamental level makes it not straightforward to tell whether the emergent properties of the mind, like free will, are purely deterministic. Free will is unlike the previous cases of thermodynamics and computing, where the emergent properties can be fully described and predicted based on the underlying deterministic laws. Just as Heisenberg and Bohr debate the implications of quantum theory in the play Copenhagen, with Heisenberg emphasizing the inherent uncertainty and Bohr stressing the role of the observer, the question of free will in light of quantum mechanics involves grappling with the tension between determinism and indeterminism in the brain.[15]

Let’s revisit the physicist Karen Barad and philosopher Henri Bergson. Barad argues in *Meeting the Universe Halfway*, that quantum indeterminacy challenges our classical notions of causality and determinism, opening up new possibilities for understanding the nature of agency and free will.[16] The mind's emergent properties, while still exhibiting some level of predictability and describability, are ultimately influenced by the complex interplay of deterministic and indeterministic processes at the fundamental level. Similarly, in *Creative Evolution*, Bergson talks about the role of indeterminism and

[12] "Quantum Approaches to Consciousness," Stanford Encyclopedia of Philosophy, November 30, 2004. https://plato.stanford.edu/entries/qt-consciousness.
[13] "Hungry Judge Effect," Wikipedia, https://en.wikipedia.org/wiki/Hungry_judge_effect.
[14] "Quantum Approaches to Consciousness."
[15] Michael Frayn, Copenhagen (1998).
[16] Barad, Meeting the Universe Halfway.

novelty in the evolution of life and consciousness. He argues that the élan vital, or vital impetus, introduces an element of unpredictability and creativity into the universe, which cannot be fully captured by mechanistic or deterministic explanations.[17] These thinkers resonate with the idea that the mind's emergent properties, such as free will, may involve a degree of indeterminism arising from quantum phenomena.

Let's organize our thoughts so far.

	Fundamental Properties	Emergent Properties
Thermodynamics	Atoms and molecules, governed by the laws of classical mechanics. (Deterministic)	Temperature, pressure, viscosity - macroscopic properties arising from the collective behavior of particles. (Deterministic)
Computation	Transistors, logic gates, and binary code, following Boolean logic and circuit design. (Deterministic)	Software, artificial intelligence - complex functionalities emerging from the interactions of simpler components. (Deterministic)
The Mind	Neurons and synapses, influenced by biochemical processes and potentially quantum effects. (??)	Consciousness, free will - higher level cognitive functions. (??)

Figure 4: Organized Examples x Properties.

6. Philosophical Implications for Free Will

What does introducing indeterminism in quantum mechanics mean for our understanding of free will? If quantum indeterminacy influences neural activity and decision-making processes in the brain, it introduces an element of unpredictability, challenging the classical notion of a deterministic universe. While microscopic quantum effects may average out at the macroscopic level, the existence of quantum indeterminacy means that the future is not entirely predictable from the past, even in principle.[18] This leaves open space for free will to operate independently of the deterministic laws of classical physics.

For example, we can look at the unpredictability arising from the complex interactions of celestial bodies in the *Three-Body Problem* series, as a metaphor for the emergence of chaotic behavior from deterministic systems.[19] The interplay between deterministic neural processes and indeterministic quantum effects in the brain suggests that free will may involve a nuanced integration of both elements. Just as the characters in the series grapple with the implications of unpredictability for the fate of civilizations, the question of free will in light of quantum mechanics invites us to reconsider our understanding of agency and responsibility.

[17] Bergson, Creative Evolution.
[18] "Free Will is as Real as Baseball."
[19] Cixin, Liu. The Three-Body Problem. 2008.

Despite the indeterminacy introduced by quantum mechanics, Norbert Wiener, computer scientist and philosopher, argues that it does not necessarily provide a more satisfactory explanation for free will than determinism. Wiener acknowledges that quantum mechanics introduces an element of indeterminism, stating that "Tyche [chance] is as relentless a mistress as Ananke [necessity]".[20] In Greek mythology, Ananke represents necessity, inevitability, and determinism, while Tyche represents chance, fortune, and randomness. By equating the two, Wiener emphasizes that both principles are equally powerful and inescapable forces in the universe. He suggests that random events are no more "free" than predetermined ones. This slightly opposing perspective to the former claims that the idea that true free will requires a level of control and rationality that goes beyond mere randomness.

A common argument in favor of the existence of free will is that you cannot run a society without assigning responsibility. But it has been shown that thoughts, intentions, and actions arise from prior causes beyond conscious control. So what can be made of this? Perhaps believing that individuals are the authors of their actions actually makes them better humans. But how we ought to think about free will is a separate discussion from what is actually happening. From a philosophical perspective, the introduction of indeterminism through quantum mechanics has important implications for the free will debate. Generally, there are three sides to this debate - determinism, compatibilism, and libertarianism. Determinists believe that free will is a complete illusion and that all events are determined by preceding events. Compatibilists believe that free will and determinism are compatible, and that individuals can be free and morally responsible even if their actions are determined by prior causes. Libertarians believe that we have the capacity to make genuinely free choices that are not predetermined by prior events. Most philosophers are compatibilists, some are deterministists, and very few are libertarians.[21]

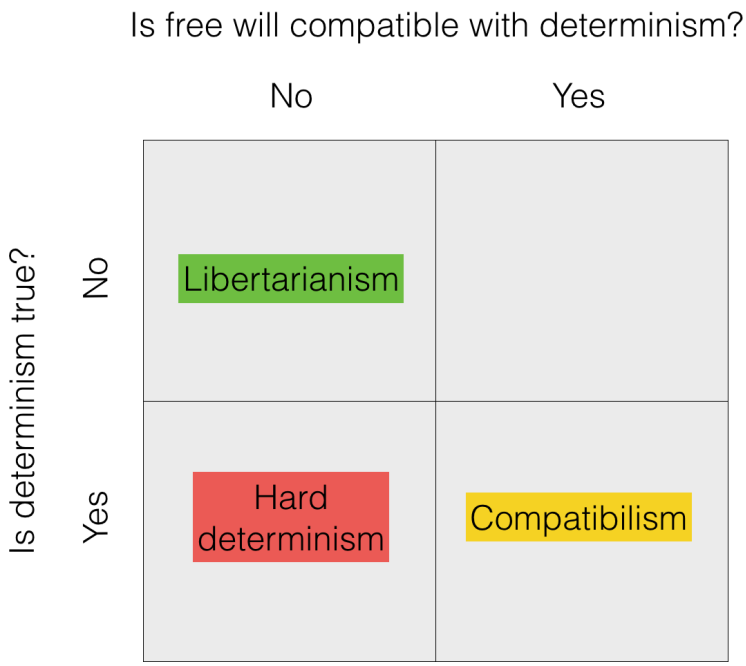

Figure 5: Three Positions on Free Will and Determinism.[22]

[20] Norbert Wiener, Newtonian and Bergsonian Time (1961).
[21] "Survey done from The PhilPapers Surveys," https://philpapers.org/surveys/results.pl.
[22] Matthew Van Cleave, "The Problem of Free Will and Determinism," University of Central Florida Introduction to Philosophy, https://pressbooks.online.ucf.edu/introductiontophilosophy/chapter/the-problem-of-free-will-and-determinism/.

Libertarian philosophers, who argue for the existence of free will, may view quantum indeterminacy as providing the necessary break in the causal chain of determinism, allowing for the possibility of genuine free choice. However, as Jenann Ismael and other philosophers have pointed out, indeterminism alone does not necessarily imply free will, as truly random events are no more "free" than deterministic ones.[23] The challenge lies in reconciling the unpredictability of quantum events with the rational decision-making processes associated with free will. Additionally, even in a quantum world, the emergent properties of the mind may exhibit a degree of predictability, as discussed in the context of weak emergence. Striking a balance between the deterministic and indeterministic aspects of the mind remains a key challenge in understanding the nature of free will in light of quantum mechanics. As Bachelard notes in *Intuition of the Instant*, habit and rational coherence play a crucial role in shaping the mind's emergent properties, suggesting that predictability and continuity can arise even in a discontinuous, indeterministic world.[24]

Wait, so even though quantum indeterminacy introduces randomness into events, this randomness doesn't equate to free will? Unfortunately, yes. Random events, like deterministic ones, are not under our control. True free will requires rational decision-making, which means making choices based on reasons, not just random occurrences. The challenge is to understand how our rational decisions can coexist with the unpredictability of quantum events.

7. Conclusion

From a classical physics perspective, the deterministic laws governing phenomena like thermodynamics and computing would seem to align free will with a deterministic framework. But quantum mechanics introduces an inherent indeterminism that opens up new possibilities for conceptualizing free will. As articulated by thinkers like Bergson, duration and lived experience inherently involve memory - the coexistence of the present with an ever-accumulating past.[25] If quantum indeterminacy significantly shapes the neural activity underpinning this flow of memory and consciousness, then free will may involve a fundamental element of novelty and unpredictability outside the causal chain of determinism.[26] Yet, even if quantum indeterminacy introduces randomness into events, this randomness doesn't equate to free will. Random events, like deterministic ones, are not under our control.

If classical deterministic processes largely dominate the brain's biochemical machinery, free will may best be understood through the philosophical lens of compatibilism—as an emergent, higher-level process consistent with (though not necessarily determined by) the underlying deterministic physical laws. The Copenhagen interpretation's acknowledgment of indeterminacy at the quantum scale while upholding determinism at the macro level provides a framework for such a compatibilist perspective. Free will may arise from an integration of deterministic and indeterministic elements that shape reality and knowledge. Rather than an all-or-nothing proposition, free will plausibly involves a nuanced interplay of random and deterministic influences.

So, is Charles Whitman an evil person or a victim of biology? From one perspective, if quantum uncertainties critically influenced Whitman's neurological activity, his tragic actions could be seen as stemming in part from an element of fundamental indeterminacy - neither fully deterministic nor fully "free" in the classical sense, but involving a departure from strict causal determinism. Alternatively, if

[23] Kevin Timpe, "Free Will," Internet Encyclopedia of Philosophy, https://iep.utm.edu/freewill/#SH4a.
[24] Gaston Bachelard, Intuition of the Instant (1932).
[25] Gilles Deleuze, Bergsonism, Chapter 3: "Memory as Virtual Coexistence" (1991).
[26] "Ancient Theories of Freedom and Determinism," Stanford Encyclopedia of Philosophy, October 30, 2020. https://plato.stanford.edu/entries/freedom-ancient.

classical deterministic processes governed his brain's compromised biochemical state, his behavior could be viewed as an inevitable outcome of deterministic physical laws, leaving less room for a traditional notion of free will. A similar struggle in ethics is seen in the play Copenhagen, where the characters wrestle with the implications of quantum mechanics for the understanding of human agency and moral responsibility. Ultimately, the extent to which one believes Whitman's tragic choices involved an element of free will likely depends on one's perspective regarding the role of quantum indeterminacy in shaping human consciousness and decision-making, and the philosophical frameworks through which these questions are interpreted, including but not limited to how even randomness does not provide true freedom.

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