Marco Masi[1]

Quantum Indeterminism, Free Will, and Self-Causation

Abstract: *A view that emancipates free will by means of quantum indeterminism is frequently rejected based on arguments pointing out its incompatibility with what we know about quantum physics. However, if one carefully examines what classical physical causal determinism and quantum indeterminism are according to physics, it becomes clear what they really imply — and, especially, what they do not imply — for agent-causation theories. Here, I will make necessary conceptual clarifications on some aspects of physical determinism and indeterminism, review some of the major objections against libertarian conjectures, and show that there is no conceptual incompatibility preventing us from taking a 'quantum-libertarian' approach to the problem of free will. In particular, I will illustrate the possible role of self-causation (causa sui) as a potential solution to otherwise apparently incompatible or even paradoxical statements concerning free will and quantum indeterminism.*

Keywords: quantum indeterminism; libertarianism; free will; randomness; consciousness studies; agent-causation; self-causation.

Correspondence:
Email: marco.masi@gmail.com

1 Phd, Independent scholar.

Journal of Consciousness Studies, **30**, No. 5–6, 2023, pp. 32–56
DOI: 10.53765/20512201.30.5.032

1. Introduction

While quantum mechanics (QM) became one of the most successful scientific theories of the twentieth century, and the predictive power of its mathematical foundation is unparalleled and unquestioned, its conceptual foundation and philosophical implications are notoriously less unambiguous. Classical realism based on concepts of local causality, determinism, non-contextuality, and what Einstein, Podolsky, and Rosen famously called 'elements of physical reality' (Einstein, Podolosky and Rosen, 1935) has been replaced by a 'quantum realism' based on notions of non-locality, indeterminism, and contextuality. The experimental demonstration that Bell's inequalities (Bell, 1964) are violated by QM implies that either reality is non-local, or reality is irreducibly indeterministic, or both.[2] Though it is still possible to frame various interpretations of QM that save a deterministic form of realism (e.g. the de Broglie-Bohm theory), quantum indeterminism is considered by most physicists to be an inherent and irreducible aspect of reality. This is also the reason why, in an experimental context requiring highly reliable random number generation (e.g. in cryptography or for Bell-tests), quantum random generators are preferred over classical pseudo-random ones.

Less consensus meets the conjectures about the possible role that quantum effects could play in brain activity, the emergence of consciousness, and its implications for free will. While quantum biology is an emerging field of investigation supported by some empirical evidence (for an update and perspective, see Kim *et al.*, 2021; or for a review, see McFadden and Al-Khalili, 2018), the hypothesis that there could be a relationship between quantum mechanical phenomena in cellular and subcellular structures, and our mental phenomenality emerging from neuronal activity, remains a controversial matter. One of the main concerns is related to the question of how quantum effects in the brain could withstand environmental thermal decoherence processes. Another objection, which received less attention but is frequently invoked as a knockdown argument, opposes theoretical frameworks that link quantum indeterminism to free will. Compatibilists argue that determinism is compatible with free will and that there is no need to invoke classical or quantum indeterminism (e.g. see Strawson,

2 Therefrom Bell's theorem: 'No physical theory of local hidden variables can ever reproduce all of the predictions of Quantum Mechanics.'

2000), whereas libertarians (or 'incompatibilists') hold that free will and determinism are mutually exclusive and, consequently, free will must be rooted in some form of indeterministic phenomena (e.g. see Kane, 2016). There is no consensus on whether the non-deterministic aspect of QM is or is not compatible with a libertarian conception of free will.

The 'quantum free will' debate is much more long-standing than normally assumed, not rarely coloured by ideological standpoints, and dates back to the 1920s, with the first speculations of Arthur Eddington, Arthur Compton, and Pascual Jordan (for an overall historical account, see Kožnjak, 2020b). Nonetheless, since the times of Schrödinger (1951/2014, pp. 164–6), several physicists tend to object to any eventuality that quantum indeterminism could have anything to do with volition (see also Carroll, 2016, p. 381; Hossenfelder 2020; Greene, 2020, p. 180). The general argument is, roughly speaking, that randomness can't be a source for a controlled agency. If quantum random effects were to play a role, they would only cause us to act randomly — that is, 'lawlessly' — and lead to the violation of the presently known laws of physics. Therefore, quantum indeterminism can't be compatible with free will.

The aim of this paper isn't so much to convince the reader of the opposite, but rather to highlight how these arguments rest on *a priori* assumptions. In the first part, I show how these are based on unwarranted assumptions and logical extrapolations resting on a popular misunderstanding of what quantum indeterminism implies for causation and free will. I first offer a short conceptual clarification of what determinism and indeterminism really mean from the perspective of classical and quantum physics. This is because misunderstandings frequently stand in the way of developing clear comprehension of the real nature of quantum indeterminism, its implications, and especially, what it does not imply.

In the second part, I will reveal how this also shows that there is no logical incoherence in rejecting the randomness argument, the second of the standard arguments against free will, and that there is no conflict between QM and free will supposedly violating the laws of physics. Another aspect that has been posited almost axiomatically in the literature is self-causation as an impossibility. Nietzsche notoriously stated, 'The causa sui is the best self-contradiction that has been conceived so far' (Nietzsche, 1886/2015), while Strawson posited this impossibility as a 'basic argument' (Strawson, 1994) from which all other arguments on moral responsibility are then extrapolated.

Nonetheless, I show how, in contrast to event-causation (an event causes an event), agent-causation interpretations (a 'being' who is not an event causing events) are not only compatible with QM in the frame of a self-causative framework, but also offer a natural interpretation of quantum indeterminism itself. A few comments to sum up will follow.

2. Classical and Quantum Randomness: What They Are, and What They Are Not

Before proceeding to my main arguments, it wil be necessary to make some conceptual clarifications that are frequently lost sight of, thereby leading to unaware conflations and logical fallacies, including among well-trained scientists and philosophers. In fact, the arguments against the hypothesis that quantum indeterminism may play a role in free will are usually based on metaphysical assumptions and conceptually unwarranted extrapolations that rely on the improper use of statistical notions.

2.1. Classical indeterminism: A few conceptual clarifications

Within physics, there is no universal definition of determinism or randomness. The simplest idea of what we usually mean by 'random events' is a set of outcomes to which equal probability is assigned, also called 'white noise'. However, the general notion of randomness involves probability distributions that are a measure of unpredictability, with 'unpredictable' meaning everything that can't be predicted with 100% certainty.

Roughly speaking, one considers as 'deterministic' all those processes for which dynamical evolution can, at least in principle, be predicted and described by natural laws in the form of a set of differential equations having a unique solution once the initial and boundary conditions are given. These seemingly sufficient characterizations have, nevertheless, a caveat. They are as valid in classical physics as they are in quantum physics. In the former case, one uses the differential equations whose solutions lead to non-probabilistic functions with definite-valued states (e.g. the equations of motion of point particles), whereas in the latter case, these are replaced by probability distributions or probability densities obtained by applying the Born rule, after solving Schrödinger's differential equations,[3] which, however, can have a unique solution as well. Therefore, so defined, the distinction between classical determinism and quantum indeterminism remains vague. Because, in classical physics,[4] determinism always presupposes value-definiteness — that is, an isomorphic identity between the physical state of an object and the measurement outcome of some of its properties in terms of physical quantities.[5]

Thereby, the classical physical causal determinism implies that, at any moment in time, the present state of a system (a point-particle, an ensemble of point-particles, but also a complex system, like a brain), with its (eventually temporally dependent) constraining boundary conditions, uniquely determines its future state and its related measurement outcomes, as a time-parametrized injective function. The future state and our measurements are already predetermined by the present, with no other possible alternatives. Each state of a dynamical system is uniquely determined by its past state and condition, while any measurement yields only one possible outcome. In short: a single value-definite cause determines only one possible value-definite effect, with the present physical state and its related measurement outcomes being a function of the past. One can express this in a somewhat more vivid manner, highlighting two aspects.

First is the initial state at time t_0 and the final state at time t_f of the system, each corresponding to only one unique point in a $\mathbb{R}^{2n}$-dimensional phase-space. Because, contrary to QM, for each classical state, when a physical quantity is measured, only one possible definite measurement outcome is possible. Second, the dynamical evolution of the system is determined by a set of differential equations for which analytic solutions are unique and, consequently, represent a unique one-dimensional phase-space trajectory between these two zero-dimensional points. Thus, in no way are these notions related to propositions having any teleological significance or implication.

---

3 Or fields in Dirac's equations or in Lagrangians in the case of relativistic quantum field theories.

4 By 'classical physics' here I generally mean 'non-quantum' — that is, relativity is seen as part of non-Newtonian but still classical physics.

5 Because measurement inaccuracy is not the cause of quantum mechanical indeterminism, throughout this paper, I will assume only ideal measurements (meaning that, according to the projection postulate, an ideal measurement projects a quantum state onto one of its eigenstates of the measured observable, leaving the system in a pure state that is exactly correlated with the measurement outcome).

Neither in physics nor in mathematics is the indeterministic character of a phenomenon a measure of its supposed lack of ‘volition’, ‘purpose’, or ‘aim’. It is this unnoticed conflation between a popular and a rigorous scientific understanding of these notions that we must be aware of.

The popularly accepted meanings of terms like ‘randomness’, ‘pure chance’, and ‘coincidence’ can be found in dictionary definitions. According to the online Cambridge Dictionary, ‘random’ is, among other things, something ‘happening, done or chosen by chance rather than according to a plan’ — that is, ‘without choosing intentionally’. The Oxford English Dictionary instead defines ‘random’ as anything ‘having no definite aim or purpose; not sent or guided in a particular direction; made, done, occurring, etc., without method or conscious choice’. These conventional notions always suggest (more or less implicitly), by a *non-sequitur* fallacy, a lack of will, agency, directedness, aim, moral responsibility, reason, plan, and purpose, equating it with capricious, uncontrolled, irrational behaviours. They present themselves as a test guaranteeing the absence of any teleological force standing behind any phenomenality. This is something that one is not allowed to do in a statistical physical context, where there is no connection between randomness and notions of agency in the sense of a common-sense everyday understanding.

The concept of probability dates back to the seventeenth century with Blaise Pascal (1623–1662), Pierre de Fermat (1601–1665), and Christiaan Huygens (1629–1695). The latter introduced, in 1657, the concept of ‘expectation value’, the average value of a random variable over a large number of experiments (for an historical account, see Hacking, 2006, and David, 1998). What we normally have in mind is the ‘frequentist interpretation of probability’ of Richard Von Mises (1883–1953), who, in 1936, defined the probability of an event as the limit of its relative frequency in many trials (Von Mises, 1936/1981). Nowadays, however, in exact sciences, such as mathematics and physics, the Von Mises frequentist interpretation has given way to a purely axiomatic approach introduced by Andrey Kolmogorov (1903–1987).

Arguments for or against speculations that directly or indirectly involve a conscious deliberation have no place in these mathematical formalizations. In this sense, probability is only an indicator of an epistemic limitation measured by a statistical prediction of specific occurrences. It is an epistemic or Bayesian probability, not an inherent physical property of the system. The closely related notion of randomness is, therefore, also an epistemic, not a naturalizable inherent property of things.

Perhaps the most notorious and rigorous definition of randomness is that based on the works of Gregory Chaitin. Chaitin's 'algorithmic information theory' established a link between the concepts of randomness and complexity (Chaitin, 1975; 2007; Downey and Hirschfeldt, 2010). To cut a long story short: 'random' includes everything that is represented by an incompressible string and, thereby, has maximum complexity. While this seemed to be a powerful and rigorous way of defining randomness, it soon turned out to be a Pyrrhic victory. This is because Chaitin himself was also able to prove that there is no way, not even in principle, to determine whether a program has this shortest length, as it is forbidden by the famous 'incompleteness theorem' of Kurt Gödel (1931). However, setting aside the absence of this conceptual closure, again, also in this theoretical framework, there is no logical connection between a supposed lack of agency and randomness.

Moreover, a measure of (un-)predictability is a relative concept: what appears to be totally unpredictable in some context might well turn out to be predictable in another one. From there comes the expression of 'deterministic randomness' which, actually, is an oxymoron. For example, we label the outcome of tossing a dice as 'random' because it is unpredictable. However, at least in principle, if one had all the physical parameters, the initial and boundary conditions of the dice, as well as a powerful numerical tool that calculated the dynamics of the tossing event, one could ideally predict the outcome. Would we then still label this process as 'random'? In classical physics, we don't perceive a contradiction between determinism and randomness.

Still, there is no direction in a random outcome of coin or dice tosses and which are non-volitional. This simple fact, however, is not an argument that allows us to imply the opposite, namely that a random sequence can't be the expression of goal-directed agency. An easy counter-example that shows how an apparently random phenomenon is fully volitional can be found in encryption technology. Mathematical encryption models have been created just for a purpose: to transform sensible information into a stream of data that a complicated informational protocol optimizes to appear by all means patternless — that is, random noise. Figure 1 illustrates a self-explanatory example.

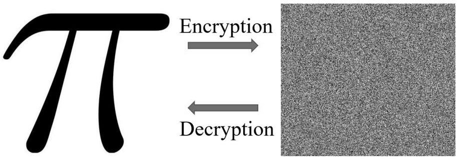

Figure 1. A meaningful symbol and its encrypted image.

What in the encryption is seen as just noise without any regularity and meaningful structure — that is, a stream of apparently ‘purely random’ data without meaning and purposeful agency — suddenly makes sense once decoded with a key or password and reveals the presence of something meaningful.

From this follows the notion that deterministic randomness is in the eye of the beholder according to what one knows, not something inherent in a process or the ‘world out there’. There are things that could be labelled ‘random’ — meaning unpredictable or having a certain degree of unpredictability — but that nevertheless are fully directed by a volitional agent. Classical statistical mechanics is conceptually and historically rooted in a Laplacian worldview of a deterministic and, at least in principle, completely predictable universe by the almighty Laplace demon (Laplace, 1814).

Thus, in science, and even less in physics, equating any statistical notion of randomness with any form of intentionality or directedness is an unwarranted conceptual conflation. The difference has no ontological correspondence and appears only in our minds.

2.2. Quantum indeterminism: A few conceptual clarifications

So, what about quantum physics? Here, one says that quantum indeterminism is ‘truly random’ because its unpredictability is not due to our lack of knowledge but, rather, is ‘intrinsic’. I contend, however, that this is, again, a bit too popular an understanding of what the scientific theory really tells us. Saying that a phenomenon is quantum indeterministic, or just ‘truly random’, means that the theory is a complete description of reality and has no hidden variables. The wavefunction completely describes the physical system, and the measurement outcomes for an observable can only be predicted by a probability distribution.

The questions, then, are: what is a ‘hidden variable’? What kind of ‘reality’ are we talking about? What does all this allow us to conclude? And, more importantly, what kind of inferences we are *not* allowed to make? Let us gain conceptual clarity first.

A physical theory is a mathematical model based on physical quantities — that is, measurable entities (in QM, the observables) quantifiable with a numerical value (in QM, an eigenvalue), amenable to algebraic manipulation — and that fits the observed measurements predicting the dynamical evolution of the physical system.

A classical theory is a complete description of the physical system when it contains all the physical quantities necessary to describe at all times the measurement outcomes in terms of definitive-valued classical observables (real-valued functions on an appropriate phase space), and once the initial and boundary conditions of the system are given. Whereas a quantum theory is a complete description of the physical system when it contains all the physical quantities necessary to describe the measurement outcomes in terms of expected values of quantum observables (bounded self-adjoint operators acting on a Hilbert space) which are obtained by applying the Born rule, and once the initial and boundary conditions of the system are given. Notice that at the level of the Schrödinger equation the dynamics is deterministic; the state vector evolves from an input state to a unique output state. In QM it is the application of the Born rule that 'breaks' the deterministic dynamics: it's only when one considers a particular observable and projects the state vector onto a particular eigenvector that one gets an amplitude.

While a theory that is not complete is a theoretical model that does not contain all the necessary information for a complete description, there exist unknown physical quantities — commonly called 'hidden variables' — that determine the observed measurement outcomes and that, therefore, the model can predict only with limited accuracy. The variables are 'hidden', meaning the current theoretical framework does not incorporate them because of a lack of knowledge, but we can visualize them, say, with a microscopic model of reality having some invisible properties. They exist and, at least in principle, are still knowable.

If this were the case for QM, it would mean that the wave-function emerges as a statistical quantity from an underlying hidden variable reality[6] (such as in thermodynamics) and that a theory exists that can

---

6 In Bell's original paper, a hidden variable appears as a continuous parameter, λ, in a probability density $\rho(\lambda)$ (Bell, 1964).

supersede QM. However, as explained above, we have good reasons to believe that this is not the case, and more sensitive becomes the question of how to interpret a theory that is complete but without definite-valued physical quantities — that is, preserving a statistical formal structure capable of making only probabilistic predictions (unlike thermodynamics).

The conceptual difficulty involved in ascribing an ontology to it arises because we have nothing to visualize since there is no missing information and no invisible properties to talk about in the first place. We cannot resort to a form of realism describing quantum phenomena in terms of a classical chain of causes and effects. No underlying ontology can be framed in our naïve human sense-mind realism. In QM, this means that a quantum mechanical system is completely specified by the state vector (or wave-function) that evolves satisfying the time-dependent Schrödinger equation and that, despite its completeness, makes (by applying the Born rule) only probabilistic predictions via expectation values. Quantum indeterminism (such as Heisenberg's uncertainty principle, the random measurement of spin states, the collapse of the wave-function, etc.) is not due to ignorance. The probability distributions involved in the theory are no longer epistemic; rather, they are inherent in the ontology — that is, are 'ontological' or 'ontic' probabilities.

As a corollary, it might also be useful to recall that, according to the Kochen-Specker theorem (Kochen and Specker, 1967), assigning definitive values at all times to observables, and independently from the measurement context, is in conflict with the quantum mechanical Hilbert space formalism (there could be no decomposition of the projection operators on the system's Hilbert space). We can't have it both ways: either we must give up value-definitiveness or we must abandon contextuality. While Bell's theorem states the mutual exclusivity between local realism and hidden variables theories, the Kochen-Specker theorem adds an exclusion rule between the latter and a non-contextual ontology. In other words, the idea that the pointer of a measuring device reveals to us an element of physical reality, or what we call in our everyday parlance a 'property' of a physical object, that is independent of the measurement act and its context — that is, how the measurement is performed — is a form of non-contextual causal realism that is incompatible with QM.

Nevertheless, in QM, the dynamical evolution of each state vector in a Hilbert space representation is uniquely determined by a time parameter: the Hamiltonian operator generates the time evolution of a quantum state with the unitary time evolution operator.[7] Or, equivalently, one calculates the propagator with the path integral formulation that replaces the unique classical trajectory with a sum over all the quantum-mechanically possible trajectories. However, this yields probability distributions for the observables — that is, of possible measurement outcomes: a single cause determines more than one possible effect. For example, in the double slit experiment, preparing a particle in some initial state (its position, its momentum — that is, its de Broglie wavelength, etc.) and setting the boundary conditions (the width of the slits, their distance, etc.) will uniquely determine the interference pattern (the probability distribution) on a detecting screen. However, at which interference fringe the single particle will be detected is an entirely probabilistic process.

Therefore, while the probability distribution is determined by the past, the potential measurement outcomes are not. Eigenstates are statistically constrained but are not functions of the past. There are aspects of the present reality with no causal dependence between its past and future. In other words, there could be observable effects that have no antecedent causes. A quantum theory without hidden variables describes an 'acausal' ontology in which events just happen and must not necessarily be what they are because of preceding causal relations with past events.

It is this temporal independence from the past, together with value-indefiniteness, that makes quantum indeterminism so peculiarly different from classical forms of indeterminism. This is what sparked the conventional expression of 'true' or 'inherent' quantum randomness, and QM being an 'inherently' or 'truly' indeterministic theory — not any ontologies supposedly telling us anything about agent-causality.

Statistically, there is nothing wrong in regarding quantum indeterminism as being 'truly' or 'inherently' random, but philosophical inferences ruling out agent-causation are unwarranted conceptual extrapolations that are based on neither the theory nor the phenomenology of QM. Unpredictability is not a signature, a proof, or a

---

[7] Notice that, from a formal point of view, the evolution operator which acts on the wave-function generates a unitary time evolution that is uniquely determined by its Hamiltonian, and is reversible: it propagates a unique quantum state to another unique one. Therefore, the dynamics is deterministic. The indeterministic character of QM always emerges in the measurement process which, formally, is represented by the application of the Born rule.

litmus test that allows us to jump to conclusions regarding a supposed lack of agency. It just means what it means: unpredictable. That's what famously puzzled Einstein, who stated: 'God, doesn't play dice.' Bohr's answer became equally famous: 'Stop telling God what to do with his dice.'

3. Quantum Indeterminism and Agent-Causation: Objections Answered

3.1. The (inconclusive) standard argument against free will

Keeping in mind this distinction, which avoids any straightforward conflation between scientific statistical concepts and the lack or presence of agent-causation interpretations, we are now in a position to briefly review the standard arguments against free will.

British-Australian philosopher J.J.C. Smart framed the two 'standard arguments against free will' in 1961 (Smart, 1961). The first objection against free will is the 'determinism objection': if all events are caused deterministically, then all our choices must be predetermined, and there can be no free will. The second is the 'randomness objection': we can be free only if our choices are free, and these are free only if they are neither deterministically caused nor nomically necessitated by antecedent events. However, a free choice that is not causally determined by antecedent events is a random occurrence and, therefore, cannot be regarded as a free action. Indeterminism can't be the cause of our freedom because any random factor induces a loss of control rather than empowering it — as signal processing scientists know all too well when they must deal with noisy sources. It is just 'noise' that has no meaning and, thereby, can't be considered a source of volition or creative power. Moreover, if any right choice we make were determined by some underlying random processes, it would, thereby, be just a matter of luck (this is the so-called 'luck objection'; for a recent review, see Moore, 2022). In short, it doesn't matter if our actions are caused deterministically or non-deterministically; either way, we can't have any control over it.

Though the main subject matter of this paper deals with the second objection, let us briefly address the first one. The first objection remains a matter of debate. Notoriously, compatibilism that sees determinism and free will as compatible has a great number of supporters (for a review, see McKenna and Coates, 2019). I, however, can't find a sensible reason for how this could be reconciled with a notion of classical physical causal determinism. We have seen that once the initial conditions and the constraining boundaries of the physical system are given,[8] a non-quantum Newtonian form of determinism uniquely fixes between two zero-dimensional points a definite one-dimensional trajectory in phase-space. Therefore, there could be no 'choice' intervening in between, making things happen differently. Otherwise, it is not a physical casual determinism. There can be no compatibility of determinism, or at least with this kind of classical physical causal determinism, with any notion of free will, because any volitional aspect has been expunged from the outset. I fully agree with the determinism objection.

Let me now focus on the random objection, rephrasing it in the context of QM. If everything is ruled by indeterministic microscopic processes, where everything seems to be ruled by blind chance, by pure coincidences, just random events, no form of will — that is, a consciousness applying itself to a goal-directed work and a result — then no control over one's choices could conceivably emerge from it. If QM were a complete theory without hidden variables where all physical laws are ultimately rooted in quantum processes, any volitional act emerging from quantum indeterminism would lead to erratic and uncontrollable behaviours. This supposedly implies that postulating any connection between QM and causal autonomy is an untenable logical fallacy.

This line of reasoning assumes (subconsciously) the naïve conception of randomness and chance as being synonymous with an undirected phenomenon, an indicator of the lack of any conscious agency. However, as we have seen, this remains an unwarranted extrapolation. There is nothing in the formalism and the conceptual foundations of QM that hooks up quantum indeterminism and quantum 'true' randomness — that is, an inherent unpredictability arising due to the absence of hidden variables — to any conceptions of an (un)guided or (un)directed agency, no more and no less than in classical physics. The action, communication, or any phenomena stemming from conscious agent-actions can appear random — that is, unpredictable — to the best statistical analysis. Randomness means

8 One might object that there should be no constraints, since an action arising due to external forces is, by definition, no longer free to do otherwise. However, we are making a concession to the compatibilist, not imposing a limitation. Because any physical system that is not subjected to external forces is even more predictable and deterministic.

only indeterminism and is not an intentional notion. Unpredictability is no sign of lack of agency or lack of control, and there is no compelling reason to believe that things are different in QM. Thus, the standard argument is, if not flawed, at least inconclusive.

3.2. Quantum indeterminism and free will: No violation of physical laws

Nevertheless, one possible objection is the following (for example, see Sider, 2007). While we might concede quantum randomness making room for agent-causation, we shouldn't forget that QM assigns probability distributions to each of these possible 'free choices' constrained by the strict laws of QM: the solution of differential equations, such as the Schrödinger equation, and the Born rule. Though the so-obtained probability distribution does not say which event will become actual, the overall behaviour of the system is strictly constrained by these quantum laws. For example, the photon diffracted at the double slit will have to hit one of the interference fringes; it can't displace itself, 'at will', on a dark band. This would induce statistical divergences in the probability distribution or density function. Therefore, agent-causation could not peacefully coexist with QM because it makes it a slave to quantum-mechanical probabilities or leads to the violation of physical laws. QM not only fails in helping the agent-causation theorists, but it also makes them 'anti-scientific'.

However, careful analysis of this statistical objection reveals the fallacy. This is something vividly illustrated in a famous essay by Elizabeth Anscombe in 1971, in which she cast doubts about whether there is a contradiction between classical micro-indeterminism and freedom of action (Anscombe, 1971). Anscombe imagined a glass box full of tiny coloured particles randomly shaken and that, by statistical fluctuations, could form patches of uniform colour. What if a meaningful word appears? It isn't obvious that this implies a violation of physical or statistical laws. More recently, her claim was substantiated by computer simulations: it is possible to implement an external control that leads to the creation of meaningful pattern formation without violating the micro-statistical laws (Müller, 2022). There is no incompatibility between stochastics and causal agency control.

In the quantum mechanical context, Randolph Clarke (2010) showed that 'probabilistic laws of Nature do not require, for any finite number of trials, a precise distribution of outcomes'. Several highly unlikely outcomes may occur, without violating the overall statistical law. A conscious agent may choose a prescribed distribution law of outcomes but there is no prescribed order to do that. An agent can freely choose how to approximate a target distribution in each case. A distribution is neither determined nor undetermined for any finite number of repetitions. It is only constrained to match the distribution law after a large number of 'choices'. Free will is compatible with quantum indetermination as long as it does not cause any observable deviations from quantum laws.

Moreover, Ruth Kastner strengthened the argument by studying the particular case of the possible violation of the Born rule by agent-causation (Kastner, 2016). Choices of complex macro-creatures are not accurately modelled by unique quantum observables on quantum states, as Sider presupposes. Human choices can't be tested by Born probabilities and Sider's claim that we are 'slaves to the probabilities' is off track.

To illustrate how there are still many 'degrees of freedom' (here, the physical and psychological connotation coincide) and why there isn't any conflict between an agent-causation theory and statistical laws, we can use an intuitive analogy, originally proposed by Federico Faggin (2021), applying it to quantum field theories. It is something we know well from our everyday experience and that shows how, whatever probability distribution is given, it can be taken neither as a signature for lack of agency nor as a violation of natural laws: the probabilistic distribution of the alphabet's letter in a written text.

Statistical analysis shows that, given a sufficiently long text in a specific language, regardless of who writes it and what one writes, the probability distribution describing the letter frequency will always be the same. For example, in the English language, no matter who is writing and no matter what he/she is writing, in the large number limit, the most probable occurrence will always be the letter 'e', appearing with a probability of about 12.7% (see Figure 2 top). Without knowledge of the language, one would see only the occurrence of an unpredictable sequence of symbols according to a probability distribution and may conclude that no conscious volition and wilful semantic agent stands behind the occurrence of these 'truly randomly' appearing letters. There is a probability distribution with the occurrence of the single letter remaining completely unpredictable and that can be characterized only by an expectation value.

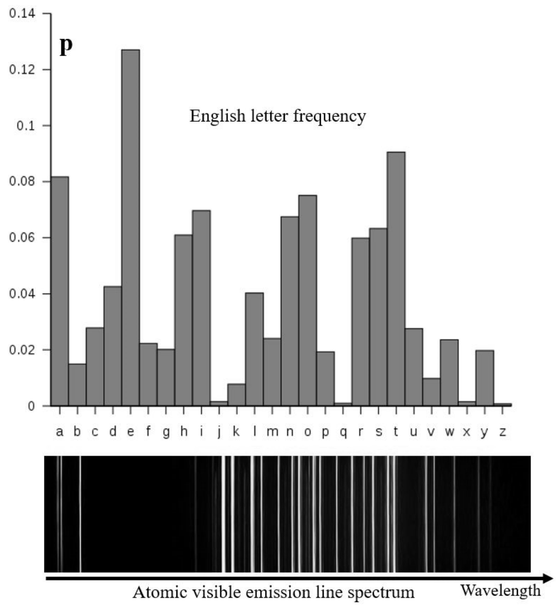

Figure 2. Top: Probability distribution of the English alphabet. Bottom: Atomic spectral emission lines. Credit: Wiki-Commons.

From the statistical point of view, this is no different to the notion of a probability distribution and expectation value that describes quantum indeterminism. To illustrate this, consider the bottom of Figure 2. It shows the emission line spectra in the visible light of an atom (Neon). It is a snapshot resulting from an exposure that collects the flux of photons in a time interval. The horizontal position of the line represents the wavelength of the photons, while its intensity (the width of the line) is proportional to the number of photons collected per unit time interval. This also dictates the probability that one will observe that the single photon hit the specific line every time the atom emits a photon. Which photon will hit which line next is an exclusively quantum process; one can speak only of the probability with which the next photon will appear on one or the other spectral line, but no matter how much we know about the quantum system, the single event remains intrinsically unpredictable.

Obviously, this is not to say that language has anything to do with quantum physics. However, this analogy highlights how there is no conceptual difference between the two statistical tests: the statistics of the occurrence of the alphabet’s letters in a text and the occurrence of that of the photon's wavelength by an atomic emission. If the former is not a test that allows for any extrapolations against teleological speculations, the latter isn't either. Arguments based on quantum indeterminism or randomness supposedly violating physical laws and/or demonstrating a lack of agency, directionality, will, or final causes are flawed logical inferences.

This also suggests a resolution of the interactionist or energy conservation objection and the luck objection at once. A theory positing free will in quantum indeterministic phenomena cannot be dismissed on the grounds of arguments resorting to energy conservation violation, no more and no less than random quantum events do. For example, in quantum field theories, one frequently gets to know about so-called 'quantum fluctuations' and 'virtual particles', which are often misrepresented as popping in and out of existence by a temporary violation of the energy conservation principle for a fleeting time interval allowed by the time–energy uncertainty relation. However, these are not 'fluctuations' or 'particles' at all, but only superpositions of eigenstates and computational devices in Feynman diagrams, respectively. What fluctuates in time are the measurement outcomes, not the state of the measured quantum object.

For the same reason, since, from this standpoint, a choice is not determined by a quantum indeterministic process, but rather *is* the very same quantum process, there is no luck problem left. Every choice is no more and no less a matter of 'luck' than the choice to use the letter 'e' in the English language with a 12.7% probability. It is not a matter of luck. It is a matter of will.

3.3. The self-causation hypothesis

The standard argument against free will hides an unnoticed assumption. Whoever invokes these standard objections assumes them to be exhaustive of all possibilities. There can be only determinism or indeterminism. What else?

By maintaining this background assumption, several approaches have investigated if and how quantum indeterminism may allow for freedom of action (for a couple of reviews, see e.g. Acin *et al.*, 2013; Hodgson, 2012). What they have in common is that quantum unpredictability is taken as an external factor to the agent, something which we could consciously recruit to build alternatives, such as the mind manipulating quantum indeterminism to produce new ideas and to generate unexpected and unpredictable behaviour, or a source to exploit — for example, by a conscious agent that makes decisions using quantum effects, or controlling the quantum uncertainty and modifying the probabilities of events. Most notoriously, Roger Penrose and Stuart Hameroff developed their 'orchestrated objective reduction' theory (Orch OR), which identifies quantum state reduction as quantum computations in microtubules inside neurons with discrete conscious moments, thereby supposedly rescuing free will (Hameroff, 2012). Quantum randomness is conceived of as something that instantiates a conscious moment or that the 'being' can access in order to freely choose, but it is not considered an inherent quality in the being itself. In all these models, free will is seen, in one way or another, as assisted by randomness, and where the agent is influenced by undetermined events. The idea that this indetermination is the manifestation of conscious causal agency — that is, will itself — is therefore neglected.

Could this latter point of view be a viable option? Let us unpack it in more detail. From a purely mechanistic and physicalist point of view, in a complete theory without hidden variables, random events just happen and are seemingly 'causeless'. Our deterministic and mechanistic understanding of the world where everything that happens must be determined by a chain of causes and effects preceding it in time, and where there must always be a reason for whatever happens, no longer holds. Leibniz's principle of sufficient reason, which states that everything must have a reason, cause, or ground, is questionable in this domain. In QM, an atomic nucleus that decays at time t_1 rather than time t_2 doesn't need 'reasons' to do so. There are only potentialities inherent in the system actualizing or not actualizing something, and which are not reducible to some mechanistic causal relations yet to be discovered. In QM, every physical event has a 'potentiality', 'propensity', 'aptitude', or 'disposition' to manifest, but must not. This is a 'cause-less' and 'reason-less' phenomenality that inflicts violence on our binary deterministic vs. indeterministic mindset and that makes the standard arguments against free will appear inescapable.

However, if we relax our physicalist causality, we may admit to a third possibility that great minds such as Plotinus, Spinoza, Descartes, St Augustine, Schelling, Hegel, Schopenhauer, Whitehead, Husserl, and the seers of the Upanishads contemplated: the '*causa sui*' — that is, something generated within itself, is self-caused, or the cause of itself and independent of any other ground, yet containing within itself a sufficient explanation of its own being, and the source of every selfmodification as a self-creative process. It is neither determined nor undetermined, but self-determined.

Spinoza begins his magnum opus, *Ethics*, stating: 'By cause of itself (causa sui) I understand that whose essence involves existence; or, that whose nature cannot be conceived except as existing' (Spinoza, 1677/2005, I, Def. I). For Spinoza, the *causa sui* was the very notion of Substance, or God, as the first cause of all things, and also the cause of Itself. This Substance, however, was not meant by Spinoza as a resting being, but as an unconditional and temporal power of action, a creative and dynamic force. 'That thing is called free, which exists solely by the necessity of its own nature, and of which the action is determined by itself alone' (*ibid.*, I, Def. VII).

Whitehead, who took a reductionist and atomistic perspective, claimed that the actual entities, the 'atomic occasions of experiences', are self-creative or *causa sui:* 'Self realization is the ultimate fact of facts. An actuality is self-realizing, and whatever is self-realizing is an actuality' (Whitehead, 1978). For Whitehead, each actual entity creates its own identity and strives for self-actualization by self-transformation. It achieves its subjective aim by becoming actual: every process is active in and of itself and reveals a drive to realize its potentialities.

According to the Upanishads there is a principle of will of our own becoming, the *svabhava* (self-expression, self-being, real-nature, truth of being) and that works out of latency by the law of action the *svadharma* (self-law, real-action, self-shaping).

The question, then, is: could we, at least in principle, interpret quantum indeterminism in the frame of a 'self-causal' ontology? Something along the lines of Leibniz's panpsychist monadology where each monad is an actual entity not only having a passive proto-conscious atomic occasion of experience but also being an active proto-volitional self-determining will? Quantum fields not just having but being minutest '*causa-sui*-propensities'?

If one posits consciousness with an inherent free-agency quality as an ontological fundamental primitive, no physical law and no logical reason prevents us from conjecturing that quantum randomness might be a local expression of a self-determining and selecting will, some sort of primitively volitional capacity, intrinsic in matter and space-time. This would, at least in part, be in line with a Spinozian universal 'substance', a *Natura naturans* at work by a consciousness-force and consciousness-will, or with Schopenhauer's vision of the 'World as Will' (Schopenhauer, 1847/2015). Alternatively, it could make sense from a panpsychist perspective or, conversely, in a cosmopsychist setting, or some other metaphysical construct. I am not going to prefer any of these but, rather, point out that these alternatives are fully compatible with what modern science knows.

Self-causation has mostly been looked upon with suspicion, if not outright rejection, as the 'best self-contradiction so far conceived'.[9] However, if instead of asking how free will relates to causation, or a lack of causation, but, rather, posit causation itself as an aspect of a volitional power expressing in what we see as quantum potentialities, its paradoxical implications with regards to an apparent incompatibility with both determinism and indeterminism dissolve.

It is a view that contrasts with and even replaces the event-causation of the mechanistic Laplacian clockwork universe — with the agent-causation — where 'being' is the agent that causes an event. In a quantum indeterministic context, the single event is a potentiality out of many (or infinitely many) possible ones with no physical selecting mechanism other than will *being* the selecting 'mechanism'. Several metaphysical approaches can be taken in accord with such a theoretical framework. Such as a Spinozian cosmology where the 'agent' is Nature itself manifesting in an infinite number of 'Substance-modes' actualized in microscopic primary acts of volition. For example, an atom 'choosing' when and which energy transition occurs next and, thereby, determining when a photon is detected at which spectral line (such as those in Figure 2). Something that, before the actual event, to an observer can appear only as stochastic and unpredictable potentialities.

Heisenberg came close to this idea with his suggestion that the statistical nature of quantum theory can be interpreted as a form of Aristotle's 'potentia' — that is, not actualities but, rather, dynamic possibilities of nature 'standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality' (Heisenberg, 1958, p. 41) (for a more in-depth historical account and recent debates, see also Kastner, Kauffman and Epperson, 2018; Jaeger, 2017; Kožnjak, 2020a). There is, however, no teleological dimension in Heisenberg's interpretation.

---

9 I guess this to be the same reason why Richard Feynman considered the idea of the electron's self-interaction, which is nowadays an accepted aspect of quantum field theories, as a 'silly and unnecessary idea' (Feynman, 1966).

Yet, here I go a step further and posit that the 'potentia' *is* self-caused will, or a 'proto-will', expressing some primitive form of volition, aim, and telos. A system in quantum superposition collapses into one outcome by no other 'hidden variable', 'reason', or 'motive' than for a self-determined act of self-actualization. This fits the definition of free will as the 'ability to do otherwise', and much more. There is nothing that contradicts the laws of QM. Quite the opposite; the most natural interpretation of what a statistical theory that is complete and without hidden variables implies *is* a theory of self-causation.

A view in which quantum indeterminism is seen from the perspective of self-causation invalidates the standard argument against free will. Because will isn't a hidden variable, it cannot be just a hidden parameter in a mathematical expression, or some unknown gear mechanism determining a probability distribution, and it doesn't need to appear as such in a wave-function or density matrix. A probability density without hidden variables is a measure of unpredictability; it doesn't tell us anything more than that. From this standpoint, quantum indeterminism reflects the existence of volition. Will doesn't require any causality. Here, we align with Schopenhauer: causality as an emergent property of will. Quantum indeterminism differs from classical indeterminism inasmuch as it is not only unpredictable for an outside observer, but is also self-determined from the inside, as there is nothing other than itself as a possible causal source or agent and that is not dependent on prior events. Will is an inherent aspect of consciousness and is free precisely and only because it is the cause of itself and doesn't need anything beyond itself or a reason or motivation to will. Or, as Schopenhauer used to say: 'Motivation is causality seen from within' (Schopenhauer, 1847/2015). And, in the context of a more recent Eastern metaphysical vision, the Indian mystic and philosopher Aurobindo Ghose describes 'the finite as a frontal aspect and a self-determination of the Infinite', where 'each self-determination of the self-being must have its own awareness' (Aurobindo, 1919).

After all, it is self-determination that we consider in our everyday parlance to be the true meaning of what we call 'freedom'. To strive for freedom *is* to strive for a self-actualization that enacts a self-realization.

4. Conclusion

I argued against the habitual tendency to connect stochastic processes to statements against teleological ontologies. There is no principle of mutual exclusivity. A scientific and philosophical approach that starts from the more or less abstract and loose notion of randomness, connecting it to unguided processes or a lack of purpose, meaning, or any kind of volition, is misplaced. Using unpredictability as a measure of a lack of intentionality leads to unnoticed but unwarranted and inaccurate statements. Statistical concepts such as randomness, unpredictability, noise, and chance do not exclude free will and conscious creativity and are not at odds with the physical laws we know so far. Thus, the arguments by randomness against free will hypotheses in any scientific context are a common fallacy lacking inferential value or explanatory power.

A quantum micro-indeterministic process that appears locally as unguided randomness can direct the formation of a non-random and ordered macro-phenomenality. What looks like microscopic noise can turn out to be a macro-structure forming process. Microscopic randomness can be a bottom-up creative power that appears random only because of the complexity of its action, which is beyond our discernable comprehension. The randomness objection based on arguments of quantum indeterminism does not hold under careful scrutiny. Moreover, conceptual difficulties arise when we exclude *a priori* the possibility of going beyond a deterministic vs. indeterministic dichotomy and conception of reality. Self-causation is not a new metaphysical category but is worth being rediscovered with its potential explanatory power to be studied further in the context of quantum-consciousness studies. What we call ‘unpredictability’, ‘noise’, ‘randomness’, and ‘chance’ might well be the backdoor for free agency.

Of course, quantum indeterminism is not evidence of free will in Nature, either. QM does not force us to such a conclusion, but nothing forbids teleological and metaphysical speculations. Ideally, science should refrain from jumping to conclusions based on one’s own metaphysical belief system and, in this regard, maintain an agnostic attitude, as long as these are not presented as a scientific fact that excludes the opposite point of view.

Acknowledgments

I would like to thank an anonymous referee whose very helpful and clarifying suggestions enhanced the quality of this paper.

References

Acín, A., Gisin, N., Brassard, G. & Raymond-Robichaud, P. (2013) Quantum physics and free will, in Suarez, A. & Adams, P. (eds.) *Is Science Compatible with Free Will? Exploring Free Will and Consciousness in the Light of Quantum Physics and Neuroscience*, pp. 7–61, Berlin: Springer. doi: 10.1007/978-1-4614-5212-6

Anscombe, G.E. (1971) Causality and determination, in *The Collected Philosophical Papers of G.E.M. Anscombe*, **2**, pp. 133–147, Oxford: Oxford University Press.

Aurobindo, G. (1919) Brahman, Purusha, Ishwara — Maya, Prakriti, Shakti, in Aurobindo, G., *The Life Divine*, pp. 336–379, Pondicherry: Sri Aurobindo Ashram Press.

Bell, J.S. (1964) On the Einstein Podolsky Rosen paradox, *Physics Physique Phyzika*, **1**, pp. 195–200. doi: 10.1103/PhysicsPhysiqueFizika.1.195

Carroll, S. (2016) *The Big Picture: On the Origins of Life, Meaning, and the Universe Itself*, New York: Dutton.

Chaitin, G.J. (1975) A theory of program size formally identical to information theory, *Journal of the Association for Computing Machinery*, **22** (3), pp. 329–340. doi: 10.1145/321892.321894

Chaitin, G.J. (2007) Algorithmic information theory: Some recollections, *ArXiv*. doi: 10.48550/arXiv.math/0701164

Clarke, R. (2010) Are we free to obey the laws?, *American Philosophical Quarterly*, **47** (4), pp. 389–401.

David, F.N. (1998) *Games, Gods & Gambling: A History of Probability and Statistical Ideas*, New York: Dover Publications.

Downey, R.G. & Hirschfeldt, D.R. (2010) *Algorithmic Randomness and Complexity*, Berlin: Springer Science & Business Media. doi: 10.1007/978-0-387-68441-3

Einstein, A., Podolsky, B. & Rosen, N. (1935) Can quantum-mechanical description of physical reality be considered complete?, *Physical Review*, **47** (10), pp. 777–780. doi: 10.1103/PhysRev.47.777

Faggin, F. (2021) The primordial quantum language, *Essentia Foundation*, [Online], https://www.essentiafoundation.org/the-primordial-quantum-language/reading/ [23 May 2021].

Feynman, R.P. (1966) The development of the space-time view of quantum electrodynamics, *Science*, **153** (3737). doi: 10.1126/science.153.3737.699

Gödel, K. (1931) Über formal unentscheidbare Sätze der Principia Mathematica und verwandter Systeme, I, *Monatshefte für Mathematik und Physik*, **38** (1), pp. 173–198. doi: 10.1007/BF01700692

Greene, B. (2020) *Until the End of Time: Mind, Matter, and Our Search for Meaning in an Evolving Universe*, New York: Alfred A. Knopf.

Hacking, I. (2006) *The Emergence of Probability: A Philosophical Study of Early Ideas about Probability, Induction and Statistical Inference*, 2nd ed., Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511817557

Hameroff, S. (2012) How quantum brain biology can rescue conscious free will, *Frontiers in Integrative Neuroscience*, **6**, art. 93. doi: 10.3389/fnint.2012.00093

Heisenberg, W. (1958) *Physics and Philosophy*, New York: Harper Row.

Hodgson, D. (2012) Quantum physics, consciousness, and free will, in Kane, R. (ed.) *The Oxford Handbook of Free Will*, 2nd ed., pp. 56–83, New York: Oxford University Press. doi: 10.1093/OXFORDHB/9780195399691.003.0003

Hossenfelder, S. (2020) You don't have free will, but don't worry, *Back Reaction Blog*, [Online], http://backreaction.blogspot.com/2020/10/you-dont-have-free-will-but-dont-worry.html [10 October 2020].

Jaeger, G. (2017) Quantum potentiality revisited, *Philosophical Transactions of the Royal Society A*, **375** (2106), pp. 1–14. doi: 10.1098/rsta.2016.0390

Kane, R. (2016) On the role of indeterminism in libertarian free will, *Philosophical Explorations*, **19** (1), pp. 2–16. doi: 10.1080/13869795.2016.1085594

Kastner, R.E. (2016) The Born rule and free will: Why libertarian agent-causal free will is not 'antiscientific', in Aerts, D., de Ronde, C., Freytes H. & Giuntini R. (eds.) *Probing the Meaning of Quantum Mechanics*, pp. 231–243, Singapore: World Scientific. doi: 10.1142/9789813146280_0009

Kastner, R.E., Kauffman, S. & Epperson, M. (2018) Taking Heisenberg's potentia seriously, *International Journal of Quantum Foundations*, **4** (2), pp. 158–172. doi: 10.1142/9781786346421_0011

Kim, Y., Bertagna, F., D'Souza, E.M., Heyes, D.J., Johannissen, L.O., Nery, E.T., Pantelias, A., Sanchez-Pedreño Jimenez, A., Slocombe, L., Spencer, M.G., Al-Khalili, J., Engel, G.S., Hay, S., Hingley-Wilson, S.M., Jeevaratnam, K., Jones, A.R., Kattnig, D.R., Lewis, R., Sacchi, M., Scrutton, N.S., Silva, S.R.P. & McFadden, J. (2021) Quantum biology: An update and perspective, *Quantum Reports*, **3** (1), pp. 80–126. doi: 10.3390/QUANTUM3010006

Kochen, S. & Specker, E.P. (1967) The problem of hidden variables in quantum mechanics, in Hooker, C.A. (ed.) *The Logico-Algebraic Approach to Quantum Mechanics*, The University of Western Ontario Series in Philosophy of Science, vol. 5a, Berlin: Springer. doi: 10.1007/978-94-010-1795-4_17

Kožnjak, B. (2020a) Aristotle and quantum mechanics: Potentiality and actuality, spontaneous events and final causes, *Journal for General Philosophy of Science*, **51** (3), pp. 459–480, Berlin: Springer Nature. doi: 10.1007/s10838-020-09500-y

Kožnjak, B. (2020b) The earliest missionaries of 'quantum free will': A socio-historical analysis, in Grgić, F. & Pećnjak, D. (eds.) *Free Will & Action: Historical-Analytical Studies on Nature, Mind and Action*, pp. 131–154, Berlin: Springer. doi: 10.1007/978-3-319-99295-2_10

Laplace, P.S. (1814) *A Philosophical Essay on Probabilities*, New Jersey: John Wiley & Son, and London: Chapman & Hall.

McFadden, J. & Al-Khalili, J. (2018) The origins of quantum biology, *Proceedings of the Royal Society A*, **474** (2220). doi: 10.1098/rspa.2018.0674

McKenna, M. & Coates, D.J. (2019) Compatibilism, in Zalta, E.N. (ed.) *Stanford Encyclopedia of Philosophy*, [Online], https://plato.stanford.edu/entries/compatibilism/ [16 November 2019].

Moore, D. (2022) Libertarian free will and the physical indeterminism luck objection, *Philosophia*, **50**, pp. 159–182. doi: 10.1007/S11406-021-00370-2

Müller, T. (2022) 'Let's build an Anscombe box': Assessing Anscombe's rebuttal of the statistics objection against indeterminism-based free agency, *Synthese*, **200**, art. 74. doi: 10.1007/s11229-022-03565-6

Nietzsche, F. (1886/2015) *Beyond Good and Evil: Prelude to a Philosophy of the Future*, New York: Warbler Press.
Schopenhauer, A. (1847/2015) *On the Fourfold Root of the Principle of Sufficient Reason*, Cambridge: Cambridge University Press.
Schrödinger, E. (1951/2014) *Nature and the Greeks and Science and Humanism*, Cambridge: Cambridge University Press.
Sider, T. (2007) Free will and determinism, in Conee, E. & Sider, T., *Riddles of Existence*, New York: Oxford University Press.
Smart, J.J.C. (1961) Free-will, praise and blame, *Mind*, **70** (279), pp. 291–306. doi: 10.1093/MIND/LXX.279.291
Spinoza, B. (1677/2005) *Ethics: Demonstrated in Geometrical Order*, London: Penguin Classics.
Strawson, G. (1994) The impossibility of moral responsibility, *Philosophical Studies*, **75**, pp. 5–24. doi: 10.1007/BF00989879
Strawson, G. (2000) The unhelpfulness of indeterminism, *Philosophy and Phenomenological Research*, **60** (1), pp. 149–155. doi: 10.2307/2653435
Von Mises, R. (1936/1981) *Probability, Statistics and Truth*, New York: Dover Publications.
Whitehead, A.N. (1978) *Process and Reality: An Essay in Cosmology*, Hoboken, NJ: Prentice Hall.

Paper received July 2022; revised September 2022.