Review of: "Doyle’s Two-Stage Approach to Free Will: A Biophysics for Real Choice?"

Thomas Dittrich[1]

1 Universidad Nacional de Colombia

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In this article, the author guides us through a veritable tour de force of the scientific basis of free will, passing from quantum randomness through all intermediate scales up to human decision making. He thereby responds to and comments on an argument brought forward recently by Robert O. Doyle, suggesting a combination of determinism and randomness as essential ingredients to achieve what traditionally is considered as free will. His collection of facts selected from theoretical physics, biochemistry, cellular biology, neuroscience, computer science, and psychology is concluded as convincing evidence in favour of Doyle's hypothesis: Free will can be explained in terms of present-day science and even be reconciled with determinism. This is a thought-provoking and inspiring article.

That sweeping over such a huge range of sciences within a good dozen of pages must result in some reduction and coarsening, even minor misconceptions, is inevitable. I would like to point out a number of issues where I think this article could well be complemented or given a sightly different sense. Following the same order from micro to macro scales as in the article –

– Quantum randomness, unlike all other sources of stochasticity, is generally regarded as a fundamental and irreducible feature of nature, as quoted also by the author. However, to my best knowledge, this question is by no means definitely settled. Quantum randomness still ssticks out as an alient element in the otherwise unitary (thus deterministic) construction of quantum mechanics. The case of quantum chaos is symptomatic: Classical deterministic chaos is suppressed in closed quantum systems, owing to the more rigorous informational limitations required by quantum mechanics.

In any case, the relevance of quantum uncertainty and quantum randomness for the debate on free will is doubtful and has been seriously questioned in response to the hypothesis that they provide a fundamental basis for the freedom of choice. This idea goes back as far as Pascual Jordan's "amplifier theory". Moreover, since living cells and in particular neurons operate at room temperature, quantum randomness is exceeded by far in its effect on cellular processes by common thermal noise.

– The article highlights the random character of genetic mutations as a prime instance of novelty and creation fuelled by noise. Indeed, in this case, random events on the molecular or even atomic level are the decisive mechanism. Remarkably, little appears to be known as to which microscopic, and hence potentially quantum, processes are involved. It would be highly desirable to understand exactly where and how the entropy is injected that drives evolution and is manifest in the diversity of life on our planet.

– Another important subject, at an intermediate stage along the way from molecular to psychological processes, are interaction and communication among neurons. On first sight, neuronal spiking appears as a sequence of discrete signals, which could give rise to the misconception that neurons exchange digital signals. In fact, spiking is a noisy process, and it is the irregular timing and frequency of spikes, both continuous parameters, that carry the information, even if single spikes could already trigger a response.

– On a larger scale, neuronal tissue can be considered as excitable matter. It has been argued that as such, it maintains itself in a critical condition, hovering between a passive rest state and overexcitable chaos. Self-organized criticality can give rise in particular to avalanches of neuronal activity [1,2]. Since they amplify weak triggering inputs to massive responses, they cold support "majority votes" among neurons. In case of equally balanced choices, i.e., "Burritan's ass situations", majority vote would explain how apparently arbitrary final decisions are determined by microscopic fluctuations.

– The author refers several times to cellular systems being situated on the borderbetween fluid and solid phases. I find this characterization somewhat unfortunate, since phases in physics are defined by the presence or absence of specific symmetry properties, such as homogeneity, isotropy, etc. Living cells share none of these. They constitute a form of matter that exceeds the conceptual framework of phases and may at best be described by advanced far-from-equilibrium statistical mechanics and many-body physics.

There remain a few more comprehensive issues that come to mind under the headline of "free will in the light of contemporary science" but deserve a profound discussion that might exceed the frame of the present article:

– The author carefully addresses the ambivalent character of randomness, as disturbing element in otherwise sound and coherent decision processes on the one hand, and as the source furnishing their creativity and originality on the other. Referring to the former facet, it has often been argued that arbitrariness represents the opposite of free will (as epitomized in Kant's motto comparing "the starry heavens above me and the moral law within me"). Concerning the constructive role, it is an open question which further factors constitute creativity, beyond a certainly necessary component of randomness.

A promising candidate is the ability to surmount a given framing and jump into a broader space, often by literally ascending a higher spatial dimension. A prototypical instance is the step from thesis and antithesis to synthesis, according to Hegelian dialectic. Another striking example is the fact that the unprovability of certain truths within an axiomatized number theory could still be proven by a human logician and apprehended by others.

In how far random generation and other high-level skills, such as complex-pattern reccognition, are involved in this capacity is not clear. Which basic neural mechanism may underly it is to my best knowledge an open question and urgently deserves in-depth study.

– A vast topic, closely related to free will, is the question of predictability and control. The difference between predictability and determinism is subtle yet crucial. Contemporary physics indicates that determinism is at most a necessary condition for predictability, but not sufficient, as the case of deterministic chaos shows. Prediction from outside, in turn, is an almost immediate precursor of predetermination (see the Oedipus saga) and thus a direct antagonist of free will. Can the creative quest for loopholes allow us to escape predictions in an unexpected direction? Does this reflect a competition between the intellectual or information-processing capacities of predicting and predicted system? Recent scientific insights in cognitive and computer science are highly relevant for this subject.

Irrespective of the validity of specific ideas put forward in this article, what it definitely shows is that even in the centuries-old debate around free will vs. determinism, often led on a highly abstract level, caring about detailed technical progress achieved in the sciences is imperative.

[1] John M. Beggs, Dietmar Plenz: "Neuronal Avalanches in Neocortical Circuits", J. Neurosci. 23, 11167 (2003).

[2] Dante R. Chialvo: "Emergent complex neural dynamics", Nature Physics 6, 744 (2010).