Reviews

Advances in Religion, Cognitive Science, and Experimental Philosophy. Edited by Helen De Cruz and Ryan Nichols. London, UK: Bloomsbury, 2016. 221 pages. US $112.00 (Hardcover).

In recent years one could observe the rise and then a slow diffusion of the cognitive science of religion. There is nothing new about approaching religious behaviors by methods available to modern science, but in cognitive science many saw an opening to religion that previously was not available. In *Advances in Religion, Cognitive Science, and Experimental Philosophy*, the editors present us with a collection of contributions that combine the relatively new field of experimental philosophy with an already somewhat fatigued field of cognitive studies of religion and apply it to religious behaviors by also considering religious thought. The central idea behind this book is to utilize cognitive approaches to religion to offer the field of experimental philosophy the methodological and conceptual resources to establish an experimental philosophy of religion.

In the first article, John S. Wilkins covers some important methodological issues by differentiating between naturalistic explanations of cognition as they relate to modern science and to religious behaviors. Religious beliefs, Wilkins argues, can produce effects that are adaptive regardless of their truth content. Scientific reasoning can offer cognitive science explanations of why some religious beliefs are adaptive but it does not confirm those beliefs. Cognitive science of scientific process also finds evolved mechanisms, but those mechanisms are also given as explanations of themselves validated through their technological effectiveness.

John Teehan presents a survey of literature from cognitive science of religion to consider implications of cognitive approaches to belief in God for that belief, especially in relation to morality and evil. Teehan at first expresses astonishment that some authors, like Justin Barrett, concluded that naturalization of religious behaviors does not present a challenge to those beliefs. Teehan states that the reaction of religious believers to cognitive science of religion is analogous to what happened after Darwin when some theologians proposed that evolutionary biology is how God creates. One theological response to cognitive science of religion is to see those processes as, in the case of some types of Christian theology, God's way of being known by human beings. Teehan's thesis is that to develop a concept of God compatible with the findings of cognitive science of religion that concept must be dynamic and evolve with our insight into those processes. If that is even possible it will then also be a revision of the concept of God beyond the so-called "classical theism." An interesting feature of this critique is that if accepted, it would have much wider consequences than just for religious concepts. If all cognitive processes are a product of evolutionary processes, which seems to be the case, then those processes apply to modern science as well. This means that our modern scientific knowledge is as dependent on our evolved capacities as is every other kind of knowledge and it therefore does not have any kind of privileged view into how things "really are."

Jason and Jon Marsh explore the question of how can there be a diverse set of religious traditions making truth claims that seem to contradict one another. They pose what they call the explanatory challenge so that there can be a philosophical experimental approach to their reflection on the origins of diversity. Versions of theism that do not respond well to this challenge are, predictably, those with exclusivist truth claims regarding a specific concept of God.

Cristine H. Legare, Rachel E. Watson-Jones, and Andre L. Souza discuss reasoning about ritual efficacy in their article. This topic is historically very important for cognitive science of religion since one of the first attempts to present a cognitive approach to religion was by Lawson and McCauley in 1993, and this article presents a useful overview of recent psychological research on perceptions of ritual efficacy. The authors examine ritual as means of controlling otherwise uncontrollable and dangerous circumstances by exploring causal cognition of ritual behaviors.

Kelly James Clark discusses whether unbelief has rational superiority over religious belief. Clark states that apparent bias for inferential reasoning among some philosophers and psychologists is not warranted given how relevant intuitive thinking is, even for those philosophers who dismiss it. Clark's argument is relevant but it is also self-limiting in insisting on defending the rationality of religious reasoning. Because of that his argument loses some of its appeal for those who do not find that problem as relevant as a more general question of evolution of cognitive capacities that produce scientific reasoning, as well as religious behaviors.

One of the editors of this volume, Helen De Cruz, together with Johan De Smedt, writes on natural theology in philosophy of religion and presents experimental philosophical research that quantitatively measures "the role of religious belief in evaluating natural theological arguments." These authors establish a correlation between religious belief and perception of strength of natural theological arguments for religious belief. This is quite predictable but it is also interesting to see their methodological proposal for experimental philosophy because through this article the relevance of the potential of the wider field of experimental philosophy can be gauged.

Benjamin Grant Purzycki and Rita Anne McNamara present an ecological theory of concepts of God's minds by placing focus on "how religious thought corresponds to features of natural and social environments." Situating religious beliefs in local contexts and paying attention to when and where people express religious beliefs is shown to be of great importance and without considering that context those beliefs become unintelligible. Religious beliefs are about norms to which people are expected to conform. This article has a very extensive bibliography that is informative beyond just the content of this article.

Claire White, Robert Kelly, and Shaun Nichols write about research in claims of remembering past lives. The authors present research on the role of memory in claims of remembering of past lives, specifically on the sense of personal identity and mechanisms that produce it.

K. Mitch Hodge writes on the fear of death and coping with loss of those close to us. Interestingly, Pascal Boyer, one of the founders of the field of cognitive science of religion, in his book *Religion Explained* dismisses fear of death as one possible source of religious behaviors. This stands out as unusual since thinking about death and possible persistence of individuals after death was, and still is, often given as a possible explanation for the origin of religious behaviors in general. Hodge's article brings this question back by presenting a philosophical case for religious ways of coping with the death of those close to us.

Overall, this interesting and valuable volume presents a series of topics that the readers of *Zygon: Journal of Religion and Science* will find helpful for keeping track of developments in the field of cognitive science of religion. However, there is no unifying theme or major contribution to experimental philosophy that stands out from this book; it reads at times more as a dialogue between analytic philosophers of religion and experimental psychologists to get their terminology straight and their research programs on track. There is too much emphasis on rationality of religious belief and on logical consistency of "classical theism" to make this book exciting, but there are enough reports on valuable research to make this book a must read for anyone interested in recent developments in cognitive science of religion.

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Fashion, Faith, and Fantasy in the New Physics of the Universe. By Roger Penrose. Princeton, NJ: Princeton University Press, 2016. 520 pages. US $29.95 (Hardcover).

In his latest book, Roger Penrose deals with three foundational problems of current physics from his particularly fresh perspective. He criticizes mainstream string theories, standard interpretations of quantum mechanics, and pre-Big Bang cosmologies inasmuch as they aim to solve profound questions while glossing over equally deep issues in our understanding of nature. In this review, I analyze Penrose's main arguments, emphasizing his presentation of the Second Law conundrum as "the most profound mystery of cosmology", and discuss his own proposals to overcome the impasse. I especially focus on the capabilities of conformal cyclic cosmology to illuminate the enigma of the extraordinarily low entropy at the Big Bang and review its capacity of success in stipulating a reset for the entropy of the universe. Even though one need not follow Penrose's tentative answers, which are not immune to serious critiques, much of his view can be shared as a sound starting point in search of "the new physics of the universe."

Introduction

One part in ten to the power of 10^{124}. One divided by one followed by 10^{124} zeros. A denominator which cannot be written down in decimal notation because there is no space enough in the known universe to set in a row 10^{124} zeros of, say, one millimeter each. This is the ridiculous probability of a Big Bang like ours giving rise to the universe we inhabit, according to estimates of entropy. It is also the most astounding and controversial number that can be linked to Roger Penrose's scientific contribution.[1] His most recent book (reviewed here) does not present much new material, but has the virtue of introducing the main conundrums in current physics from his vantage point. He has never been a mainstream physicist, but who should be, given the current impasse of cosmology? (Mangabeira Unger and Smolin 2015).

Fashion, Faith and Fantasy in the New Physics of the Universe follows the lectures offered by the author at Princeton University more than a decade ago in a nontechnical jargon (technicalities are reserved for the appendices). The tone is highly critical of the fashion for superstrings, of physicists' faith in quantum mechanics, and of cosmological theories' fantasies when trying to explain away the Big Bang for different reasons. And that is probably why one can often share Penrose's criticisms while occasionally remaining skeptical about his own proposals, especially when providing a solution *obscurum per obscurius*. Nevertheless, his insights should be made known to any physicist and philosopher who wishes to understand where the problems in our understanding of nature really lie. In this essay, I will review the three more relevant problems, in keeping with the book's structure, and focus on the Second Law puzzle.

Functional Freedom vs. String Theories

Penrose invokes functional freedom as the main setback haunting string theories. As is well known, string supporters devise a universe with 9 + 1 (or 10 + 1 in the case of M-theory) dimensions which hopefully ease mathematical calculations and make room for finite answers. If one wishes to apply such view to our homely perception of a 3 + 1–dimensional world, some very good argument needs to be made on why one need not care about the remaining 6 (or 7) spatial dimensions. Let us listen to Penrose's strong interrogation in this regard: "How is it that the highly thermalized matter degrees of freedom in the very early 9-spatial supra-dimensional universe could somehow have adjusted themselves so as to leave the extra 6 dimensions so apparently completely unexcited, as string theory appears to demand? One must also ask what gravitational dynamics could have produced such an enormous discrepancy in the different spatial dimensions, and question especially how it could have so cleanly separated the 6 curled-up unexcited dimensions from the 3 expanding ones" (197).

But that is not the only question related to arguments of functional freedom. "What happens to the floods of excessive degrees of freedom that now become available to the system, by virtue of the huge functional freedom that is potentially available in the extra spatial dimensions?" (41). One can raise serious doubts regarding their being under control. Moreover, "the logical implication of the string theorist's extra spatial dimensions would be a completely unstable universe, in which these extra dimensions would be expected to collapse dynamically, with disastrous consequences for the macroscopic space-time geometry that we are familiar with" (69). Initial restrictions on the ground state—for example, use of Calabi-Yau geometries for the extra dimensions—to avoid such instabilities cannot take over the general dynamics of space-time. Curvatures are expected to become infinite at some point, precluding the emergence of any quasi-classical space-time. Even for string theories, the singularity theorems of general relativity—culminating in the work of Hawking and Penrose (1970)—loom large.

Perturbations of space-time lead to singularities irrespective of supersymmetry arguments. Of course, one may always resort to symmetry-breaking arguments to cope with the departure from exact supersymmetry actually observed in nature. However, such selection procedures seem to be hardly justified. The huge number of inequivalent vacua (available ground states) in M-theories—10^{500} possibilities for the moduli of Calabi-Yau spaces—paves the way for recurring to dubious selection arguments in the string community, as invoking some sort of anthropic principle (119).[2] Even though it is not immediately evident how to address the functional freedom issue in a general quantum context, the odds are more unfavorable, because "the wave function involves a functional freedom that is far higher than that which manifests itself in reality, or at least in that aspect of reality that is revealed as the result of a quantum measurement" (198). Apart from instability problems, string theories must face up to a noted trouble in philosophy of science: there is no isomorphism between our most basic theories and nature, so that further prescriptions and selection rules need to be introduced almost by *fiat*.[3]

Beyond Quantum Mechanics

This situation leads to Penrose's consideration of quantum mechanics and physicists' faith in it, perhaps because "there are no observations whatever, to date, which contradict the expectations of the theory" (124). As is well known, the standard interpretation of quantum mechanics considers two basic, fundamentally irreducible, processes: the deterministic evolution of the wave-function according to the Schrödinger equation, once the initial conditions have been settled (U-process); and the indeterministic wave-function collapse into one of the possible outcomes, after performing a specific measurement (R-process). This is the measurement paradox. Penrose shows the inconsistencies and insufficiencies of trying to develop an R-process in the macroscopic world from an allegedly more basic U-process in the microscopic realm. Contextual and cognitive aspects appear as essential ingredients in our interpretation of quantum mechanics. For instance, "the particle-like aspects of photons do not come about from their wave functions having . . . a highly localized nature. They come, instead, from the fact that the measurement being performed happens to be one that is geared to observing their particle-like characteristics" (157). In null measurements, on the other hand, the state of the system necessarily "jumps" even when it does not disturb the measuring device (172). There seems to be something very subtle regarding how our cognition deals with nature. The wave-function presents ontic and epistemic features which must be considered together at the same time, if one wants to make sense of what is going on out there.

None of this is solved with alternative quantum mechanics interpretations conducive to double ontologies, as the Bohmian picture or the resort to environment-induced decoherence. Nor with many worlds interpretations, where "we may definitely question why human experiences are to be allowed to un-superpose a given quantum state into two parallel world states, rather than maintaining just one superposed world state—which is what the U-description actually provides us with" (207).[4] Accordingly, "to get a proper solution to the measurement paradox, we need a change in the physics, not just some clever mathematics, brought in to cover the ontological cracks" (206). And he sets out to work: with clever mathematics, as provided by his twistor theory using non-localities of holomorphic cohomology possibly linked to the puzzling non-local aspects of quantum entanglement and measurement; and with new physics, making current quantum mechanics and its linearity a provisional theory until gravity may properly be taken into account. For Penrose, the final answer must give precedence to the principles of relativity theory. His cue is that "[A]ll quantum state reductions arise as gravitational effects. . . . In many standard situations of quantum measurement, the main mass displacements would occur in the environment, entangled with the measuring device, and in this way the conventional 'environmental decoherence' viewpoint may acquire a consistent ontology" (215). In other words, environment-induced decoherence may become ontologically univocal only when subsumed into gravity-induced objective reduction of the wavefunction.

Struggling with the Second Law

All in all, the most ambitious new physics conjured up by Penrose aims to answer "the most profound mystery of cosmology" (258): the extraordinarily tiny entropy at the Big Bang as represented by the number with which this review begins. There are many other cosmological problems and many other proposals which try to extend standard Big Bang cosmology to inflationist or pre–Big Bang scenarios, as suggested by the presence of correlations in the small deviations from uniformity of the cosmic microwave background which extend over wide angles of the sky (307). Fantasy is needed for the new physics, but current proposals fall short of solving the singularity problem, singularities remaining even in the quantized theory. The claim that singularities would not persist when asymmetrical generic perturbations are introduced turned out not to be correct because "for local situations of gravitational collapse, once a trapped surface has occurred, singularities cannot be avoided, for physically reasonable classical material, quite irrespective of any assumptions of symmetry" (239). Singularities are but a generic feature of gravitational collapse.

Nevertheless, all these problems point to the deep connection between the Second Law of Thermodynamics and the nature of the singularities in space-time structure. Paying heed only to statistics, one would obtain a contradiction with the Second Law if the procedure is applied to the past direction of time. Quite the contrary, the Second Law works because of the existence of an extraordinarily macroscopically organized initial state of the universe (250). Beware! The entropy of the universe does not increase because the universe is expanding—this expansion being essentially adiabatic. In fact, one could have a big crunch with a final state in a very tiny scale with huge entropy. "The answer lies in the fact that there can be an enormous entropy gain once we allow significant deviations from spatial uniformity, the greatest gain resulting from those irregularities leading to black holes. A spatially uniform Big Bang, therefore, can indeed be of hugely low entropy, relatively speaking, despite the thermal nature of its contents" (255).

Whereas the universe can be partially thermalized at the very beginning in its non-gravitational degrees of freedom—as the black-body shape of the cosmic microwave background suggests—it is completely out of equilibrium regarding gravity. "[T]he entropy was low in a very particular way, and apparently only in the way, namely that the gravitational degrees of freedom were, for some reason, completely suppressed. . . . To my mind, this is perhaps the most profound mystery of cosmology and, for some reason, it is a still a largely unappreciated mystery!" (258). Contrary to many cosmologists that gloss over the Second Law, Penrose rightly points out where the conundrum really lies: the unknown origin of the Second Law and the impossibility of its stemming from ordinary physical evolution, defined by time-reversible equations and random initial conditions.

Some corollaries must then be underscored. First, the emergence of life on the Earth does not need whatsoever such absurd smallness in the Big Bang entropy. It is much less expensive—in entropic terms—to make lots of small habitable universes than it is to make just one big universe like ours—also habitable, as a matter of fact. The emergence of brains—the so called Boltzmann brain paradox—out of sheer randomness is thermodynamically much cheaper than the cost of an evolving universe with galaxies, stars, and planets, where life and evolution may eventually appear. The anthropic argument is thus futile and can be made redundant. Gravity on its own, via star formation, seems capable of getting low entropy photons necessary for the emergence and sustainability of life, for which one does not need the thermalized cosmic microwave background relic. Consequently, our universe's bio-friendliness possesses a highly non-local character, a feature very seldom recognized or tackled by most physicists and biologists.[5]

Second, even though inflationary models succeed in predicting the right fluctuations in the cosmic microwave background, they become wanting in giving an answer to the existence of the Second Law. They use it, but they cannot explain it. Moreover, none of the current proposals for extending cosmology beyond the standard Big Bang theory "explains the fantastic discrepancy between (a) the wild high-entropy geometry of black-hole singularities and (b) the extraordinarily special geometry of the Big Bang" (333). The Big Bang singularity cannot be understood whatsoever as a time-reversal black-hole singularity, and perhaps that is what inspires Penrose for leaving aside quantum theory and thinking in terms of the type of geometry that must have held sway in the vicinity of the Big Bang. The upshot is his conformal cyclic—or crazy, in his words—cosmology.[6]

Penrose's proposal is highly geometrical in motivation, aiming at compliance with the Weyl curvature hypothesis. "The Weyl curvature hypothesis asserts that any space-time singularity of past type—i.e. from which timelike curves can emerge into the future, but not enter from the past . . . —must have vanishing Weyl tensor, in the limit as the singularity is approached inwards from the future along any of these timelike curves" (373). Benefitting from Tod's mathematical argument—that our Big Bang can be conformally represented as a smooth spacelike 3-surface, across which the space-time is, in principle, extendible into the past in a conformally smooth way—the author assigns physical reality to the pre–Big Bang region, from which massless particles such as photons could pass through the Big Bang from *before* to *after* it, that is, from the previous aeon to the next one. At the Big Bang, the rest masses of all particles become insignificant. The conformal extension gives them a past. Rescaling the space-time metrics with a global factor, different for each aeon but leaving invariant the null-cone structure at each point of space-time, the transition at the Big Bang can be made smooth. Some more technical points linking the rescaling factors with the emergence of mass (and dark matter) need to be introduced, but the procedure seems clear enough without the need for invoking subtle quantum gravity effects.[7] "What would have been the inflationary phase of each aeon is replaced by the ultimate exponential expanding phase of the previous aeon (382). Circular correlations at the cosmic microwave background—a very controversial issue at the moment (see, e.g., Moss, Scott, and Zibin, 2011; Gurzadyan and Penrose 2010; 2013)—should provide traces of pre–Big Bang activity—e.g., inhomogeneities in the supermassive black-hole distribution—in previous aeons.

Fare well, what happens next with the Second Law? Quite surprisingly, in my opinion, Penrose relies on the loss of dynamical degrees of freedom inside black holes—which will eventually evaporate due to Hawking radiation roughly after 10^{90} years—to postulate a redefinition of the universe phase space, and accordingly of entropy, in the transition zone between aeons (382–83). Somehow, the loss of information is possible because the U-linear process of quantum mechanics no longer rules when gravity does take over deep inside black holes. Then, the Second Law is *transcended*: "[B]y the time all the black holes have completely evaporated away in an aeon . . . , the entropy definition that would initially be employed as appropriate would have become inappropriate after that period of time, and a new definition, providing a far smaller entropy value, would have become relevant some while before the crossover into the next aeon" (386).

Unfortunately, it is difficult to avoid the impression that Penrose is sweeping under the rug. At this point, one can at least reveal the following drawbacks and inconsistencies:

(1) Such a line of reasoning contradicts what the phase space of the universe means, turning useless Boltzmann's definition of entropy. If one fully endorses Penrose's conformal cyclic cosmology, there is no possible comparison of entropies among aeons. Or is there? It is highly unclear how a smooth transition between aeons can be maintained in parallel with a strong discontinuity in the definition of entropy for each aeon.

(2) Is the (alleged) redefinition of entropy a local (dependent on each black-hole evaporation, with a local end of time) or a global phenomenon occurring in the universe "some while before the crossover into the next aeon"? What is the meaning of "while" in such a statement, when time itself becomes meaningless? Is not the rescaling in the space-time metrics affecting the counting of microstates and the global entropy of each aeon? Little is known about the physics inside black holes and invoking an overall loss of information tries to find out an explanation *obscurum per obscurius*. Indeed, for the information loss paradox to ensue, additional speculative assumptions are necessary, there being a strong link between black holes, the issue of information loss, and the very measurement problem (Okon and Sudarsky 2017).

(3) Last but not least, a methodological point seems relevant here. One cannot base all reasons supporting the extremely low entropy at the Big Bang on the calculation of black holes' entropy, providing an entropy value of around 10^{124} as a possibility for the space-time singularity constituting the initial state of the universe as stated by the Bekenstein-Hawking formula, whereas

later rejecting the black-hole entropy to make conformal cyclic cosmology work. Even though "there is still no totally convincing and unambiguous procedure for obtaining the Bekenstein-Hawking black-hole formula from the general Boltzmann entropy definition" (106), the figure 10^{124} may not be neglected. If black holes' entropy cannot even be ignored in the ekpyrotic crunch-to-bang transition (332–33), neither should it in conformal cyclic cosmology!

Conclusions

The easy summary of Penrose's search of a new physics of the universe is this: string theories must be replaced with twistor theory, standard quantum mechanics with gravity-induced objective reduction of the wave-function, and beyond-Big-Bang cosmologies with conformal cyclic cosmology. Easy, but unfair to a physicist who succeeds in conveying his worries regarding excessive fashion, faith, and fantasy in current scientific endeavors. Are there ulterior reasons for his criticisms? Yes, there are. String theory's requirements of extra spatial dimensions get along badly with the beautiful links between our experienced universe and Lorentzian 4-space, so much beloved to Penrose (393). There should also be a limit to our quantum faith (126): the underlying duality of quantum mechanics could be superseded paying heed to the principles of relativity, because the principle of equivalence should be more basic than the principle of linear superposition (395). Quantum gravity is, according to the author, not really what cosmologists should be looking for; one reason among others being that no quantum-gravity theory is necessary to understand the Big Bang and its extraordinarily low entropy.

Do these reasons suffice to follow Penrose? Probably not. But he is to be followed in his scientific honesty, acuteness, and humility in dealing with current problems in the foundations of physics without dodging them. Actually, he has already been defined as "a scientist who transcends the boundaries of science, seeking the ultimate meaning of things, and thus he behaves like a philosopher" (Herce 2016, 692). A physicist who continues endlessly struggling to reach some truth, instead of ill-founded opinions, and a natural philosopher who acknowledges his epistemic shortcomings. Does it all mean to take a step forward to religion and transcendence? Not necessarily, but it shows how the house of science itself possesses open windows inviting scientists to see through them. In the end, "how does one wade through the multitude that is there largely because it is a multitude, rather than because it contains ideas, either new or old, that have genuine substance, coherence, and truth? It is a difficult question and I can supply no clear answer" (394). Nor can I, but gratitude and recognition among scientists and believers are well-deserved for Penrose and his proposals.

Notes

1. This estimate for the entropy at the Big Bang also appears in Penrose (1989, 344; 2004, 730) with the exponent 10^{123}, and in Penrose (2010, 127) with the exponent 10^{124}.
2. It can be shown that anthropic principles tend to become circular arguments and beg the (scientific) question (Sánchez-Cañizares 2014, 239).
3. As explained by van Fraassen—inspired by Kant—"the ability to self-attribute a position with respect to the representation is the condition of possibility of use of that representation"

(2008, 257). If a scientific theory aims to represent nature, scientists need to self-attribute their position in that very representation. Scientific models can thus hardly achieve isomorphism with the whole nature. "[T]o use a theory or model, to base predictions on it, we have to locate ourselves with respect to it" (van Fraassen 2008, 261).

4. This problem is related to the famous quantum factorization problem, which cannot be solved without recourse to exceptional initial conditions and/or dynamics for the system (Tegmark 2015, 265-66).

5. As an exception, see Smolin (2013) and Mangabeira, Unger, and Smolin (2015).

6. For a more detailed account, see Penrose (2010).

7. However, this procedure seems to miss some crucial points. What is weird about gravity is that, according to most relevant theoretical models, it should be the first interaction to decouple from the ur-interaction, allegedly wholly symmetric. But gravity is the latest interaction in taking over the macroscopic evolution of the universe—the formation of stars and galaxies. Why does gravity need to break symmetry so early after the Big Bang, if the formation of atomic nuclei and atoms is carried out by nuclear and electromagnetic interactions? The role of gravity seems to be subtler at the first moments of the universe than believed by Penrose. That is one of the reasons why a theory of quantum gravity is mandatory in order to understand the first moments of the universe. Contrary to what Penrose says, quantum effects must play an essential role at the Big Bang. In fact, quantum fluctuations in the inflationary era are deemed to be amplified via gravitational processes in the early universe (Dodelson 2003), determining what astronomical structures came into existence (Ellis 2016, 105).

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