BOOK REVIEWS

Jeremy Butterfield (ed.), ***The Arguments of Time***. New York: Oxford University Press (1999), 253 pp., $65 (cloth).

Commissioned by the British Academy to celebrate its centenary in 2002, *The Arguments of Time* is a collection of nine articles on the topic of time. Reflecting the healthy bias that philosophical investigation into time is best pursued in an interdisciplinary fashion, the book offers insights into time through chapters on philosophy, physics, literature, linguistics and cognitive neuroscience. Many of these chapters are original and outstanding in quality. The result is a significant contribution to the philosophy of time. Of the recent anthologies in philosophy of time, this one is my favorite.

In commenting on the collection, I focus on chapters most likely to be of interest to readers of this journal. But I should mention that the chapters by James Higginbotham on tense and indexicality and by Gregory Currie on time in literature are both readable and worthwhile.

The four papers in philosophy of physics are excellent. Let's begin with a real gem, Karel Kuchar's "The Problem of Time in Quantum Geometrodynamics." Kuchar is a distinguished physicist specializing in general relativity and quantum gravity. The paper corresponds to a talk he has given to various philosophical audiences. I'm pleased to report that the paper is as elegant as the talk. The paper explains Gauss' *theorema egregium* (that the total curvature is proportional to the scalar curvature) using only an umbrella and intuitive concepts applied to the umbrella. He then shows that Einstein's field equations are Gauss' *theorema egregium* modified by a matter term. In this pedagogical masterpiece, this exposition happens over six pages without any real equations! Continuing at more or less this level, he moves to quantum gravity, the Wheeler-DeWitt equation, and the problem of time. Finally, he evaluates various strategies for dealing with the problem of time. The chapter is remarkable in that it will appeal equally to the nonexpert and expert; the beginner will enjoy its extreme clarity and accessibility, while the expert will appreciate its elegance and the many advanced comments thrown in 'between the lines'.

The "Emergence of Time in Quantum Gravity," coauthored by the philosopher Jeremy Butterfield and the physicist Chris Isham, is a very useful discussion of the idea that time might be 'emergent' in quantum

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gravity. When it comes to speculations arising from quantum gravity, the idea that time might not be fundamental is among the most startling and exciting. As one thinks of a temperature field as 'emergent' from fundamental particles in motion, one might entertain the idea that time itself is defined in terms of something more fundamental. But does this idea really make sense? After discussing the concept of emergence in detail, Butterfield and Isham argue that in the abstract the idea of emergent time is coherent. Implementations of this idea in both canonical quantum gravity and quantum cosmology, however, are problematic. After providing a survey of some of the problems, the authors set their sights on interpretations and misinterpretations of Hawking and Hartle's so-called 'no boundary' proposal. Butterfield and Isham cleanly separate the problem of time in quantum gravity from the problem of quantum cosmology. The former is the problem of 'finding' a time in a solution to the Wheeler-DeWitt equation, whereas the latter is the problem of motivating a particular solution to the Wheeler-DeWitt equation. Hawking and Hartle still owe us a solution to the former problem, even if we accepted their rationale for the no boundary solution.

As readers of Julian Barbour's *The End of Time* know, Barbour sees in the Baierlein, Sharp, and Wheeler formulation of general relativity the near-fulfillment of some Machian aims in dynamics. In particular, in this '3+1' formulation of general relativity and its variants, one can in principle determine a complete spacetime from two three-dimensional spatial geometries. Thinking in terms of superspace, the space of all three-dimensional spatial geometries, we can think of spacetime as a path through superspace. The path that 'best matches' points of superspace seems to be empirically equivalent to general relativity for worlds like ours. In "The Development of Machian Themes in the Twentieth Century" Barbour describes—in his own inimitable style—the fascinating prehistory of these ideas, introducing a cast of characters new to many of us (Föppl, Hoffman, Reissner, and more).

Finally, in "Relativity, Time Reckoning and Time Series" the historian and philosopher of science, Roberto Torretti, tackles the topic of measured time intervals between events in special relativity and the topic of closed curves in general relativity. The topics of duration and synchronization in special relativity are well-worn ones, to be sure, but Torretti brings to them his historical viewpoint and characteristic clarity. The same can be said for his discussion of general relativistic spacetimes that contain closed timelike curves or singularities.

The papers by J. R. Lucas and Michael Tooley, respectively, are more squarely philosophical investigations into time. Both argue for dynamic (tensed) conceptions of times in which only the past and present are real. Lucas argues for a kind of traditional *A*-theory of time, while Tooley opts for a theory that is a hybrid between the traditional tensed and tenseless theories of time. Tooley wants to conceive of the world as one wherein tenseless states of affairs successively come into existence, where what is actual depends on what time it is. He also advocates a kind of causal theory of temporal priority, in which the existence of spacetime points at one moment can 'give rise' to spacetime points at other times. What motivates temporal dynamism are inadequacies found in existing theories of counterfactuals and causation. No doubt due to space constraints these inadequacies are only mentioned but not described or developed; as a result the reader not already knowing Tooley's position may feel it is inadequately motivated.

Lucas's essay aims to show that contemporary science is compatible with objective tenses. Far from ruling out tenses, contemporary science, and in particular quantum mechanics, positively suggests the existence of tenses according to Lucas. The collapse of the wavefunction, interpreted realistically, suggests a picture of a fixed past (wavefunctions collapsed to the eigenstates of the relevant observable) and an open future (wavefunctions as superpositions of such eigenstates). However, Lucas only sketches this tantalizing suggestion. We are not told, for instance, what basis this happens in. Is the past fixed in the position representation but open in the momentum representation? Nor is one told how we should view future measurement of systems already in eigenstates of the relevant observable. Are they open because future or fixed because eigenstates? Along the way, Lucas defends tenses from virtually every objection aimed their way in the past century. Not surprisingly, in covering so much ground, the arguments go by a bit quickly. Still, as always, he produces an entertaining essay packed with ideas.

Despite constantly appealing to temporal experience, few philosophers of time have studied it from the perspective of science. Those who have rarely also study the neural mechanisms responsible for this experience. The chapter "Perception of Time" by the cognitive neuroscientist Michael Triesman, therefore, seems to me an inspired choice by the editor. After some highly contentious but ignorable statements in the introduction, Triesman considers various models of biological clocks that will satisfy the dual and often competing demands of judging duration while coordinating motor control. The former requires accurate clocks and the latter flexible clocks. Triesman then compares his model with data from various timing mechanisms in the brain. He ends with the stimulating thought that unlike the nose and tongue, which sample molecules, and unlike the eyes and ears, which sample environmental energies, our time sense is due to the brain itself—the brain is the 'sense organ' for time.

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