



BOOK REVIEW

Carlo Rovelli

THE ORDER OF TIME

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Carlo Rovelli's new book covers a plethora of different perspectives on time. Included are scientific, philosophical, mundane, historical and cultural viewpoints. *The Order of Time* is written in an enthusiastic, lively manner. Rovelli wrote the original version in Italian, and it was translated to English by Simon Carnell and Erica Segre.

In the introductory section, Rovelli notes that time is inextricably tied to human life and our familiar experience of the world. We live in time like fish in the water. Time flows. This seems unquestionably true and universal. Yet "reality is often very different from what it seems", contends Rovelli. "Neither is the structure of time what it seems to be: it is different from this uniform, universal flowing", he continues. Rovelli admits that the nature of time remains somewhat of a mystery. This is comparable to other unsolved scientific/philosophical issues, like the origin of the universe and its life, and the nature of mind and consciousness.

The first part of the book (Chapters 1–5) begins with an observation that the variable t , which designates the evolving of things in time, has figured prominently in many equations of physics. This encompasses the foundations of Newtonian dynamics, Maxwell's electromagnetism, Schrödinger's equation, and quantum field theory that describes the behavior of subatomic particles. The rest of the chapter centers around physical theories that pertain to time, namely the central results of relativity, thermodynamics, and the quantum theory. These results are radically at odds with our commonsensical picture of time. Physics debunks the unity of time and its unidirectionality. Rovelli's favorite example is the demolition of the present moment. For him, this "is the most astounding conclusion arrived at in the whole of contemporary physics". Due to time dilation, there is no cosmically extended now (here Rovelli

does not lean on the relativity of simultaneity, which implies that the past, the present, and the future are all equally real). In his summary, modern physics teaches us that time “is like holding a snowflake in your hands: gradually, as you study it, it melts between your fingers and vanishes”. Then Rovelli goes on to assess the role of time-keeping and clock synchronization technologies that have appeared during history. Aristotle’s relationism and Newton’s absolutism are compared, and Einstein is presented as synthesizing them with equating gravitational field and space-time. The first part ends by considering the ramifications of quantum mechanics—granularity, indeterminacy, and the relational aspect of physical variables—each one destroying “further the little that was left of our idea of time”.

The second part (Chapters 6–8) is more philosophical, including an argument for process metaphysics, a take on the presentism/eternalism and tensed/tenseless language debates, and discussion on the relational character of time in light of elementary quantum mechanics. The last part (Chapters 9–13) considers the relation between physical time and human perception of it, how temporal experience may be emergent, how we necessarily always have a particular perspective on things, the primacy of entropy over energy, causality and asymmetry, personal identity and selfhood, neural basis of temporal cognition, and the phenomenology of time. Rovelli concludes that “the world *is* a quantum one”, so “in the elementary grammar of the world, there is neither space nor time”. The most fundamental level of reality (that we know of) has little resemblance to the time we experience in our lives.

The scope of the book is wide and impressive. I cannot think of a detail that *The Order of Time* omits. My review cannot therefore deal with the whole book. Below are my two cents on the aspects that I found most intriguing and controversial.

One of the most insightful points in the book is the explanation of our experience of the direction of time. For us, the events of the world always proceed from past to future, never *vice versa*. We do not remember the future or predict the past. To explain our experience of time’s arrow in chapter 2, Rovelli leans on Boltzmann’s idea: we see irreversible thermal processes because of our blurred vision of the world:

The difference between past and future is deeply linked to this blurring. . . . So if I could take into account all the details of the exact, microscopic state of the world, would the characteristic aspects of the flowing of time disappear? Yes. If I observe the microscopic state of things, then the difference between past and future vanishes.

I found this to be very convincing, perfectly naturalistic explanation. There is no need to posit consciousness that is somehow emerged from the physical of whose property time's arrow would be. Nor is there a need for a Kantian *a priori* forms of sensibility, which putatively dictate the direction of time to us. On a macroscopic scale, it is utterly improbable that entropy would decrease. The increasement of disorder in our environment gives us the arrow of time. No dubious emergentist or suspect transcendental arguments are needed. The direction of time is a matter of the scale at which we are looking at the world.

A central argument of the book seems to be that time is not fundamental or ultimate, or even that time does not exist. In chapter thirteen, Rovelli puts the point as follows: "We can see the world without time: we can perceive with the mind's eye the profound structure of the world where time as we know it no longer exists". If I understand this assertion correctly, the author tries to establish that deep down the world is without time (the title of the second part of the book is "The World Without Time"). So Rovelli entertains with the idea that time does not exist. But he does not elaborate on the notion of 'real.' He thinks it is a fuzzy one. In chapter seven, he claims that the answer to question of what is 'real' "is that this is a badly put question, signifying everything and nothing. Because the adjective "real" is ambiguous; it has a thousand meanings." It is easy to agree that the term 'real' is multifaceted. But I think this is a crucial concept, something which should be spelled out. When reading the book, I found it difficult to grasp what is meant by the timelessness of the world, or the unreality of time. Although Rovelli does not say that time is an illusion,¹ I think he does imply that, among others, order, direction, and flow of time are not elementary features of reality. I can think of three challenges to this argument.

First, if time is equated to temporal order, there is a way to argue for a partial temporal structure (Rovelli mentions this in Chapter 3). If light, or any other electromagnetic spectrum frequency, from an earlier event reaches a later event, this order does not change. This temporal order is invariant. All observers agree that the sending of the signal is before, and the receiving of the signal is after. Special relativity shows that an absolute, objective, and universal distinction between past, present, and future does not exist. And it indeed shows that "the 'present of the universe' does not exist", as Rovelli writes. The special theory is in tension with the A-theory of time and presentism. But the theory still retains the immutable temporal order of before-after relations à la the B-theory.

¹ Some commentators, like Andrew Jaffe in his *Nature* [review](#), read Rovelli as claiming that time is an illusion.

Second, Rovelli maintains that as the world is made of events, not things, there are ongoing processes deep down. Events are dynamic as opposed to static things. “Change is ubiquitous”, he proclaims. In his view:

The entire evolution of science would suggest that the best grammar for thinking about the world is that of change, not of permanence. Not of being, but of becoming. (...) We can think of the world as made up of *things*. Of *substances*. Of *entities*. Of something that *is*. Or we can think of it as made up of *events*. Of *happenings*. Of *processes*. Of something that *occurs*. Something that does not last, and that undergoes continual transformation, that is not permanent in time. The destruction of the notion of time in fundamental physics is the crumbling of the first of these two perspectives, not of the second. It is the realization of the ubiquity of impermanence, not of stasis in a motionless time.

As Rovelli sees the world ultimately as a network of events, there is change. If there is change, it sounds strange to say that there is no time.² Arguably the most pervasive theme one can find in the history of philosophy of time (paradigmatically, in the work of Aristotle) is that time is a measure or dimension of change. If there are physical processes it seems there is temporality. Compare this to Parmenides’ or McTaggart’s classical arguments for the unreality of time. Parmenides thought that because describing the world with temporal concepts is contradictory, reality, as opposed to what it seems, is changeless and therefore atemporal. In a similar vein, McTaggart argued that the A-series is internally contradictory, because an event cannot have all three A-properties, past, present and future. We are left with the B-series. Its before-after relations do not necessarily indicate earlier and later than relations; the C-series encompasses some type of before-after relations, ordering of letters and numbers, for example. But it contains no change and hence no time. And there is the more recent defense of anti-realism about time that comes from Barbour, who contends that motion is an illusion, and therefore time is unreal. If change is essential to Rovelli’s metaphysics, why not time? The two are intimately connected. Rovelli does not explain how change and time could be sharply distinguished.

Third, although I found the Boltzmannian idea of blurring as a source of our experience of the direction of time convincing, time’s arrow should not

² Confusingly, Rovelli claims in this section that “if by ‘time’ we mean nothing more than happening, then everything is time. There is *only* that which exists in time.” It is difficult to square such claim with another claim made at the beginning of the same chapter, which alludes to the “destruction of the notion of time in fundamental physics.”

be conflated with its flow. The former cannot be located on molecular level, but the latter can. Thermal processes involve change. Warming up means more agitation of molecules and *vice versa* for cooling down. And change is a very good candidate for our experience of the passage of time. We do not get the unidirectionality of time from change alone, but it is feasible that a sense of passage is rooted in perceivable change (this is roughly Hume's argument). If we could see atomic motions or vibrations, this could give us the notion of flow without a direction.

Rovelli has written an intricate and thought-provoking book. It treats the convoluted problem of the nature of time from multiple perspectives. *The Order of Time* is truly a versatile book. I also very much appreciate the kind and courteous way of writing. Rovelli does not aggressively attack the views he disagrees with. For example, he is very critical of presentism, but leaves room for people to disagree with him, like Lee Smolin and George Ellis. In footnote 34 he notes:

Both insist that there must exist a privileged time and a real present, even if these are not captured by current physics. Science is like affection: those who are dearest to us are those with whom we have the liveliest disagreements.

I wish such politeness would become the model for intellectual debates across the board.

I strongly suggest the book for anyone interested in the study of time. It is a beautiful inclusion of rigorous science, insightful philosophy and fine poetry. However, I do not think it achieves what I understood to be its main goal, to wit, a proper account of the world without time. To combine my three critical points, Rovelli fails to show that the world is essentially timeless, because: 1) there is temporal order, earlier and later, in special relativity; 2) assuming his event-metaphysics, change is fundamental, and as change is intimately connected to time, there is something temporal deep down; 3) change is consistent with non-directional passage of time.

