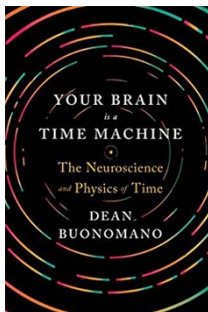


The eternal question



Your Brain is a Time Machine: The Neuroscience and Physics of Time

by Dean Buonomano

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For physicists, the idea that time simply forms the fourth dimension is almost hardwired. So how do we reconcile that with the fact that the present somehow feels special? Or perhaps more accurately, how do we convince the world at large to incorporate our eternalist mathematics into the everyday human experience? Dean Buonomano grapples with these questions in his book *Your Brain is a Time Machine: The Neuroscience and Physics of Time*.

It's fair to say that Buonomano has spent a lot of time thinking about time. A professor of neuroscience and psychology at UCLA, his research focuses on neurocomputation, and how the brain processes temporal information. I was fortunate enough to attend the London stop on his worldwide book tour, to hear highlights from his narrative while I was reading the book.

And it's clear that Buonomano's catalogue of the brain's temporal machinery is vast and varied. The book explores our semantic preoccupation with time, and our endeavours to understand it. It details our body's remarkable ability to measure time — from circadian proteins to the neural oscillators responsible for breathing. It also explains how these mechanisms fail on a supraproduct scale: although biological clocks are adept at timing intervals less than or equal to the period of their oscillator, counting these oscillations to measure longer intervals requires more complicated emergent behaviour.

Buonomano lauds the human brain's ability to predict the future — or engage in mental time travel, as he would have it. He cites our mastery of agriculture, reducing the stockpiling behaviour of squirrels to a mere reflex, and argues that with few exceptions, humans are unique in their ability to project themselves into the future.

Indeed, even within the human spectrum, our time-travelling abilities vary. Behavioural economist Keith Chen has found that people speaking languages that don't distinguish grammatically between the future and the present (dig up your high-school German or Chinese) are more suited to saving for retirement and less likely to wind up obese. The idea is that if you communicate in a futureless language, the future is far easier to imagine (watch his TED talk at <http://go.nature.com/2sw55X8>).

But the true focus of the book is not on how we measure time, or travel through it in our minds, but how the feeling of time passing can be reconciled with the framework of modern physics, in which time's flow seemingly has no place. Buonomano distinguishes the presentist view — that only the present is real — from eternalism, for which the past and future are just as real.

He assembles two arguments in favour of presentism. The first asserts that our perception of time flowing has no evolutionary advantage in the framework of eternalism. The brain's capacity for mental time travel motivates the sowing of crops, but the sensation that time marches ever forward shouldn't confer a gain if all points in time are considered equal. The second is that consciousness is a dynamic process: sleep is distinguished from wakefulness by the frequency of brain oscillations, so consciousness would seem to rely on time flowing.

The converse arguments for eternalism are all familiar: the 'now' is just as unremarkable as the 'here' within laws of physics; special relativity casts simultaneity as a subjective notion; and certain solutions to the equations of general relativity imply that time travel is possible. In fact, time travel may be the best way to settle the debate between presentism and eternalism, because the question is moot in the former view: you can't travel to the future if it doesn't actually exist.

The evidence for eternalism is all compelling, but it's difficult to ignore the feeling of time flowing and of the present being unique. Buonomano quotes Brian Greene's admission that although his intuition is that the brain imposes on time "a quality of its own making", at the end of the working day, he's more open to the thought that science is simply incapable of understanding "a fundamental quality

of time that the human mind embraces as readily as the lungs take in air".

And maybe that's what it comes down to — rational thought grappling with the human experience. I approached Dean after his talk, and asked him flat out whether he was a presentist or an eternalist. "Presentist," he said out of the corner of his mouth, after a sidelong glance. "But more importantly, what are you?" I felt compelled to respond with a kneejerk, "Eternalist!" But the more I thought about it, the surer I became of my answer.

Perhaps the clash is simply one of culture. The task of using one's brain to study the brain must carry with it a set of questions that no physicist need encounter. And the methods of gathering empirical evidence in neuroscience and physics certainly differ. My companion at the talk — a physicist — quickly dreamed up a number of ways one might probe the question of presentism versus eternalism. "Find a baby," he started, and I could already tell the ethics boards weren't going to react well. "Make it wear virtual reality goggles," he continued, "and simulate its whole life at 0.99 times the speed of light..." Needless to say, we won't be reading about the experiment he went on to propose anytime soon.

Ultimately Buonomano's tale is cautionary: our presentist tendencies are such that although we can engage in mental time travel, we value the now too much to adequately plan for the future. In his talk, Buonomano cited the now-famous Stanford marshmallow experiment designed to test children's ability to sacrifice immediate gratification in favour of future rewards (see, for example, https://youtu.be/QX_oy9614HQ). A more frightening example is our current inability as a species to preserve a distant future that we'll be able to live in — at least on this planet.

Your Brain is a Time Machine is nothing if not an entertaining read — and Buonomano is an engaging speaker, in case your paths ever cross. But as my companion noted after an evening of post-talk discussion: "I have a title for your review: 'Lots of great questions, very few answers.'" This needn't be a criticism. I certainly found much to think about when reading the book, even if my questions went largely unanswered. □

REVIEWED BY ABIGAIL KLOPPER