

RETHINKING A KEY ASSUMPTION ABOUT THE NATURE OF TIME

J. C. N. Smith

To move forward is to concoct new patterns of thought, which in turn dictate the design of the models and experiments. Easy to say, difficult to achieve [1].

- - Edward O. Wilson

Abstract. This essay challenges an assumption, far too commonly held within the scientific community, that the operational definition of time is the final word of science on the nature of time, an assumption ripe for rethinking. The essay proposes a view of time which *complements* the operational definition, and, in so doing, dispels a glaring disconnect between modern science and what generally is viewed as common sense.

1 Introduction

The triumphant march of physics, which began in earnest in the 16th century with the work of Galileo and which continued largely unabated into the 20th century with Einstein's theories of relativity and with the development of quantum theory, owes much of its success to a simple concept known as the operational definition of time: time is that which is measured by clocks. It is this definition which has allowed us to express many of our discoveries regarding the laws of nature in concise mathematical form.

To be clear from the outset, the purpose of this essay is **not** to find fault with the operational definition of time, which is, after all, simply a definition, and, moreover, an extremely important and useful one at that, having been key to the development of mathematical statements ranging from those setting forth Newton's laws of motion to those expressing Einstein's theories of relativity, along with many others.

Rather, ***the purpose of this essay is to highlight and to challenge a largely unspoken and pernicious assumption which, I believe, is held by far too many in the scientific community: that the operational definition represents the final word of science on the nature of time.*** This all-too-common assumption, has, I suspect, led to untold missed opportunities for science (especially physics) to advance at a pace surpassing even the impressive pace actually achieved. It is an assumption which has persisted abetted by a complacency bred of its own undeniable success; it is an assumption ripe for rethinking.

2 Background

2.1 Prerequisites for Conducting Science

There are a few basic things upon which I believe we must agree in order to conduct science: 1.) that there is a real universe; 2.) that the universe has - - at least on a macroscopic level - - some real (albeit intrinsically unknowable and evolving) configuration; and 3.) that observers who are local to one another and who are not moving at speeds approaching the speed of light relative to one another can be in reasonably good agreement about the configuration of at least some relatively small portion of the observable universe. Lacking these basics, science simply would not be possible, in my view.

2.2 What May We Believe About the Nature of Reality?

It is important to ask at the outset what sorts of things we may safely believe about the nature of reality. Unfortunately, the list of these things is dismally short. Over the course of history, some of our simplest, seemingly most intuitively obvious empirical observations have misled us badly, such as the long-held, incorrect beliefs that the sun revolves around the Earth and that the Earth is flat, to mention just two of many incorrect beliefs which ultimately were corrected only by making - - and thinking deeply about - - yet other empirical observations. Despite the obvious fallibility of our *interpretations* of empirical observations, such observations ultimately have proven, over the long run, to be our best, and perhaps ultimately our *only*, reliable guide to what we may hold true about the nature of reality.

2.3 Our Most Primitive, Bedrock Empirical Observations

Arguably one of our most primitive empirical observations is that the things we are able to observe around us are arranged in some particular way or configuration. Another primitive observation is that the arrangements of the things we observe around us are not always the same. The arrangements of things relative to one another are subject to change; the configuration of the observable universe is subject to change. I maintain that it is these changes in the configuration of the universe which we perceive as the flow of time.

3 Confronted With Incompatible Views

Since the beginning of recorded history, our empirical observations have led to conclude that there are real and important distinctions between the past, present, and future. For example, our empirical observations lead us to believe that in the past the Earth was populated by large, living creatures which we call dinosaurs, whereas I believe most would agree that such creatures do not inhabit the Earth at present. This would *appear* to be a *real* distinction between the past and the present.

Reasoning which is based on the operational definition of time, however, has led to the current mainstream view of physics - - concisely expressed by Einstein as follows: "For those of us who believe in physics, the distinction between past, present and future is only an illusion, however tenacious this illusion may be" [2]. According to this view, commonly known as block time, or a block universe, there is no objective flow of time. Physicist Brian Greene explains the concept, asserting that:

In this way of thinking, events, regardless of when they happen from any particular perspective, just *are*. They all exist. They eternally occupy their particular point in spacetime. There is no flow. . . . It is tough to accept this description, since our worldview so forcefully distinguishes between past, present, and future. But if we stare intently at this familiar temporal scheme and confront it with the cold hard facts of modern physics, its only place of refuge seems to lie within the human mind [3].

Which of these fundamentally incompatible views of reality should we believe, and why? Is it possible that this is merely the most recent example of our being misled by a faulty interpretation of our empirical observations, as was the case in our belief that the sun revolves around the Earth? Yes, of course this is possible. On the other hand, however, when reasoning which is based on the operational definition leads to a claim that some of our most primitive and longest-held empirical observations are illusory, should we not -- at a

minimum -- question not only the validity of our interpretations of our empirical observations but also whether the operational definition, together with any reasoning and theories based on it, are perhaps being extended beyond their rightful range of applicability?

I maintain that we can reconcile these two apparently incompatible views if we are willing to look beyond the operational definition of time and adopt a broader, more comprehensive view of the nature of time. Unfortunately, this is a step which too few in the scientific community seem willing even to contemplate, much less to adopt.

4 The Rationale for Block Time

It is illuminating to examine the reasoning used by proponents of block time to justify this admittedly counterintuitive notion. Brian Greene, for example, builds a case for block time by describing how observers located in different parts of the universe will have different conceptions of what exists at any given moment. Moreover, Greene argues, if two observers are located sufficiently far away from one another (billions of light years in Greene's example) their conceptions of the sequence of events at these two, far distant locations may be altered arbitrarily and dramatically simply by making relatively minor alterations in the observers' locations and motions. Greene then goes on to argue,

*So: if you buy the notion that reality consists of the things in your freeze-frame mental image right now, and if you agree that your now is no more valid than the now of someone located far away in space who can move freely, then reality encompasses all of the events in spacetime. . . . Just as we envision all of space as really being out there, as really existing, we should also envision all of time as really being out there, as really existing, too" [3]. [Greene's italics]*¹

But I maintain that we should *not* buy this notion. Observers, in general, have no way of forming a valid freeze-frame mental image of the totality of reality, and observers who are located far away from one another certainly have no way of forming a valid freeze-frame mental image of one another's conceptions of reality. Due to limitations imposed by sensory data, any one observer's perceptions represent little more than a "best

¹ I do not intend to single out Brian Greene for criticism. In fact, my references to his writings might be seen as a heartfelt compliment. Greene, more than many others, has given deep thought to these issues and, moreover, has expressed his thinking in a manner which is sufficiently clear that his ideas may be cited as good examples of the thinking of those who, whether by default or otherwise, are proponents of what I consider to be dubious conclusions allegedly stemming logically from the operational definition of time.

approximation” of what objectively exists in whatever portion of the universe is accessible to that observer. Moreover, the reliability of these best approximations decreases as distance from the observer increases. Our perception of the history of our own local portion of the universe certainly is far more authoritative than the perception of this same history as viewed by an observer located billions of light years away.

Given such real-world limitations, I cannot agree to the leap of logic which would lead us to conclude that because different observers will have different best approximations of what objectively exists (with no one of these best approximations being any more intrinsically valid than any other), we must agree that a multitude of objective realities coexist. The universe has one, and only one, real history, albeit one which may be perceived differently by different observers.

5 A Closer Look At the Operational Definition

In taking a closer look at the operational definition, which simply defines time as being that which is measured by clocks, we see that it appears to be a perfectly fine and reasonable definition. It establishes a relationship between the word “time” and measurements produced by physical devices called clocks. Beyond establishing this relationship, however, the definition does not have anything more to say about the underlying nature of reality.

Perhaps it is at least slightly surprising, therefore, that reasoning which is based on this definition leads to a theory - - special relativity - - which in turn leads to reasoning which purports to reveal some extremely deep insights into the underlying nature of reality. Specifically, such reasoning purports to reveal that perceived distinctions between past, present, and future are illusory. This is a remarkable revelation indeed, given that there is nothing about the operational definition which purports to establish any connection whatsoever between the word “time,” or “clocks,” and that which is meant by the words “past,” “present,” and “future.” If we seek to understand the meaning of these latter three words, or any possible connection between these words and the operational definition or special relativity, we must look elsewhere.

6 The Meaning of Past, Present, and Future and the Flow of Time

Although it may come as a surprise to some, there are coherent, logically consistent ways of thinking about the nature of time which do not require us to deny the reality of perceived

distinctions between past, present, and future, and which do not require us to deny the reality of our primitive perception of a flow of time. Such ways of thinking will not be discovered or embraced, however, so long as we continue to assume adamantly that the operational definition of time is the final word of science on the topic of time. As Edward O. Wilson insightfully observed, “To move forward is to concoct new patterns of thought, which in turn dictate the design of the models and experiments. Easy to say, difficult to achieve” [1].

For a glimpse of what such a new pattern of thought regarding the nature of time might entail, please consider this question: how, exactly, does the particular time at which I am reading this sentence differ from the particular time five minutes prior to my having read it? How does it differ from the particular times one hour or one day or one year or one century prior to my having read it? Upon some reflection you might conclude (correctly, I believe) that the differences between these particular times can best be characterized and defined, in the final analysis, by describing differences in the configuration of the universe at each of these particular times. The configuration of the universe to which we refer - - roughly speaking - - as 200 million years ago included large, living creatures - - dinosaurs - - located on the planet Earth. The configuration of the universe which we refer to as today does not include such creatures on the planet Earth. I maintain that these are real, not illusory, differences between these particular past and present times.

If you are willing, at least for the sake of argument, to grant that these distinctions are real, then it is only fair to ask how the particular time which we refer to as 200 million years ago became the particular time which we refer to as today. The answer is amazingly simple: the many bits and pieces which made up the universe 200 million years ago and which were configured to include dinosaurs roaming the planet Earth have since been rearranged rather dramatically, courtesy of the law of physics. The planet Earth persists, albeit in somewhat altered form, but only fossilized remnants of dinosaurs remain as empirical evidence that they once inhabited the Earth.

What we *perceive* as the flow of time is, in reality, nothing more and nothing less than the evolution of the physical universe, an evolution which is governed by rules which we strive to understand and which we refer to as the laws of physics. There is nothing mysterious about this.

This view of time not only *allows* us to retain our intuitive sense of a real distinction between past, present, and future, and not only *allows* us to retain our intuitive sense of a

flow of time, but it actually *requires* us to retain these concepts as part of our understanding of the fundamental nature of time.

7 Leaving the Operational Definition Unscathed

The view of time proposed here, if accepted, would not require us to abandon or in any way to repudiate the operational definition of time, *per se*, or any of the many useful theories such as Einstein's theories of relativity which are based on it. It would, however, require us - - at a minimum - - to rethink, and likely to repudiate, some of the ideas which are believed by many to stem logically from the operational definition. These almost certainly would include a repudiation of the notion that the distinctions between past, present, and future are illusory, and a repudiation of block time or a block universe in which all times - - past, present, and future - - are equally real and in which there is no objective flow of time. I suspect that these changes might be viewed by many as being not only tolerable, but perhaps as welcome and long overdue.

8 Not To Tar All Scientists or All of Science With the Same Brush

To be fair, many scientists have *not* adopted the notion that the operational definition is the last word of science on the nature of time. Notable among these are physicists Julian Barbour and Lee Smolin, who, along with some others, have long been engaged in the pursuit of other, better, ways of thinking about the nature of time [4], [5], [6].

Yet others, however, too often have made what appears to be a perfunctory nod toward the idea that there may be other, better ways of thinking about the nature of time, but after having done so they have continued to go on conducting science as though the operational definition were, in fact, the final word on the subject. Brian Greene, for example, wrote:

Time is a subtle subject and we are far from understanding it fully. It is possible that some insightful person will one day devise a new way of looking at time and reveal a bona fide physical foundation for a time that flows. Then again, the discussion . . . [which explains and apparently supports the concept of block time], based on logic and relativity, may turn out to be the full story. Certainly, though, the feeling that time flows is deeply ingrained in our experience and thoroughly pervades our thinking and language. So much so, that we have lapsed, and will continue to lapse, into habitual, colloquial descriptions that refer to a flowing time. But don't confuse language with reality. Human language is far better at capturing human experience than at expressing deep physical laws [3].

To which I would reply, “by the same token, please don’t confuse what are mathematical descriptions of reality with the underlying objective reality itself.”

9 Conclusion

I hope to have given at least a glimpse of the notion that there are valid ways of thinking about the nature of time which do not require us to abandon what many have long considered to be among our most primitive empirical observations regarding the reality of distinctions between the past, present, and future, and which do not require us to abandon our perceptions about the reality of an objective flow of time.

Moreover, and perhaps equally important, they do not require us to abandon the beneficial aspects of the operational definition of time, serving to complement rather than to undermine the operational definition. They would, however, require us to abandon an unspoken assumption that the operational definition is the final word of science on the nature of time. Adopting such a new and innovative way of thinking about the nature of time, based on a paradigm which I believe more accurately reflects the underlying objective nature of reality, could only have long-term beneficial effects on science [7].

References

- [1] Edward O. Wilson, *The Diversity of Life*, W. W. Norton & Company, Inc., Castle House, London, 1993.
- [2] Jürgen Neffe, *Einstein: A Biography*, Farrar, Straus and Giroux, New York, 2005, Translation by Shelley Frisch, 2007.
- [3] Brian Greene, *The Fabric of the Cosmos: Space, Time, and the Texture of Reality*, Alfred A. Knopf/Random House, New York and Toronto, 2004.
- [4] Julian Barbour, *The End of Time*, Oxford University Press, New York and Weidenfeld & Nicolson, London, 1999.
- [5] Lee Smolin, *The Trouble With Physics*, Houghton Mifflin Co., New York, 2006.
- [6] Sean Carroll, *From Eternity to Here: The Quest for the Ultimate Theory of Time*, Oneworld Publications, Oxford, England, 2011.

[7] J. C. N. Smith, Toward a Helpful Paradigm for the Nature of Time,
<http://sites.google.com/site/smithjcnparadigm/> , 2012.