TIMELINES

SHORT ESSAYS AND VERSE IN THE PHILOSOPHY OF TIME

EDWARD A. FRANCISCO

Timelines

Timelines is an original work of philosophy on the subject of time. It is presented in an unusual format, consisting of brief essays and essay-like verse compositions on key topics – supplemented by extensive citations – in the debate among theorists and researchers on the nature of external (physical) time and time as we experience it. This book is organized into two main sections: the first covering key issues in the study of external time and the second covering theories and challenges in the study of our experience of time, known as phenomenology. Together, these topics constitute a very large field of investigation and theory development and they have attracted neuroscientists, cognitive scientists, psychologists, theoretical physicists and philosophers.

Two central conclusions are presented and supported throughout this analysis. First, it is maintained that most of our conventional beliefs about external time are mistaken. And second, that many of the properties and dynamics of subjective time are different, complex and not well understood while being immensely important for understanding consciousness, the continuity and clarity of self, the experience of concurrent perceptual and temporal events, and ethical agency.

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ALSO BY EDWARD FRANCISCO

Fragments: Poems and Narratives

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For all theorists, philosophers, scientists, engineers, inventors, architects, and explorers who have worked to ask and answer large questions.

“Time present and time past
Are both perhaps present in time future,
And time future contained in time past.
If all time is eternally present
All time is unredeemable.
What might have been is an abstraction
Remaining a perpetual possibility
Only in a world of speculation.
What might have been and what has been
Point to one end, which is always present.
Footfalls echo in the memory
Down the passage which we did not take
Towards the door we never opened
Into the rose-garden.”

T. S. Eliot
“Burnt Norton”, *Four Quartets,* 1941.

“Time is nature’s way of keeping everything from happening all at once.”

Graffiti, Pecan Street Café, Austin, Texas, as recorded by John Archibald Wheeler, physicist.

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The Phenomenology of Time (continued)

Introduction

This small book is about time: what we can say that it is and how we experience it. Thinking about time is difficult. It appears profoundly real yet elusive. And, in thinking about it, we quickly fall into puzzles and traps.

Does time 'pass' or 'flow', and if so, in one 'direction' only? Are 'the present', 'the past' and 'the future' proper parts of time or are they only broad and even incoherent terms used to denote order and duration? And, if time can be said to have parts or stages or phases, is it continuous or discontinuous, perhaps composed of temporal atoms? Indeed, can we coherently hold that time *is* composed in some way, particularly if its constituents are non-durational instants? Can we say *when* 'the present' – or any other temporal part -- begins or ceases to exist, that is, can we defensibly assign clear points *in* time to parts *of* time? And if we consider temporal parts or references like 'future', 'present' and 'past' can we coherently define their boundaries? Or should we say that such references are merely informal and do not commit us to any formal distinctions or boundaries between them?

These are some of the thorny issues that theorists and scientists continue to consider: all undertaken in an effort to analyze and model the properties of time, especially time as encountered in the external physical world. Other theorists have adopted a contrarian position. They are skeptical about time, maintaining either that it is an illusion, does not exist at all, or exists only extrinsically and derivatively as a construct that is dependent on real physical processes.

These and many other questions will be addressed in this book. I have taken a novel approach to them, combining short essays and compact verse forms with rigorous philosophical comment. My reasons for adopting this approach boil down to three: to make the subject and its complexities generally accessible in a compact format, to reflect the great range of thought and controversy among philosophers and scientists that has appeared during the past century of thought, and to point to some of the subtleties of time that are more easily captured in nuanced verse forms rather than long discursive sentences.

The first section of this book investigates the nature of physical (external) time: whether it exists as an independent feature of reality, and if so, its principal properties. Doing this requires an overview of the prevailing agreements and controversies among philosophers and physicists regarding the nature and implications of time. The second section investigates the phenomenology of time, i.e., time as it is experienced and represented. Doing this requires attention to the most prominent modalities of temporal experience including working memory, episodic and semantic memory, anticipation and prediction of future events, the role of personal and shared historical narratives, the weight of prior events and the actual experience of present and prior events.

Each topic is presented in a dual format. In compact essay and verse format on each right-hand page, I take a position on a single topic about time. And facing it, on the left-hand page, I provide some front notes in elaboration of, and support for, the position taken in verse form.

It is certainly interesting that many who think about time think that it does not exist. At least not in the substantial sense of existing in its own right as a fundamental feature of reality. Most theories of time struggle to construct an analysis of time that is both coherent and persuasive. One of the most coherent theories – the block universe theory based on the four-dimensionalism of relativity – yields a counter-intuitive result, namely that past, present and future are either illusory or co-exist in the same tenseless way, such that every event on a worldline within a light cone has – relatively – the properties of being jointly 'past', 'present,' and 'future'. From a realist perspective, such a theory doesn't seem like a reasonable representation of time in which prior events are held to recede from present events and future events are only possibilities. That is, they are held to be different. And for some theorists there are no future facts of the matter at all, i.e., either the propositions expressed by future-tensed statements do not have 'truth-makers' and are therefore false or they are only predictions that turn out to be accurate or not.

Equally, temporal realists are generally uncomfortable with the notion that prior events have the same standing as present ones. They are therefore skeptical of growing-block theories that hold that

past and present events both exist – in some shared sense -- whereas future events do not. And, in the middle of this spectrum of theories, we find presentists holding that only present events exist or are 'real' in some sense. Yet, in its simplest form, presentism also seems wrong to many realists on the basis that [i] few events occur in infinitesimally brief 'present' intervals; [ii] the present cannot be extended enough without getting into the past and even the future; and that [iii] after Einstein, there are only countless actual and possible *presents* but no such thing as *the* present. Further, presentists struggle to defend a theory of the boundaries between prior, present and future, often positing complex and overlapping (or diffused) intervals between them.

Underlying these efforts and puzzles is the even deeper question of the nature of change: namely, what are its properties, and do we understand it? The provisional answer to this question, surprisingly, is that we do not. Once we examine the elements and structure of change, we are quickly confronted with deep issues of logical inconsistency. A brief discussion of these issues is provided in the first section of this book. Also, questions about change quickly bring us onto even larger philosophical concerns with the sorts of things that can change, such as particulars, properties and processes. Time, therefore, as a subject of inquiry, penetrates many related and equally difficult subject areas.

At the level of theoretical and empirical physics (classical mechanics, relativity and quantum theories), we appear to have well-grounded (though evolving and incomplete) models and hypotheses of what is going on. Nevertheless, 1998 Nobel Laureate Robert Laughlin (2005, p. xiv) has weighed in against strict physical reductionism – i.e., the posture of attempting to explain all states and events on the basis of the smallest detectable or theoretical parts – arguing instead that "nature is regulated not only by a microscopic rule base but by powerful and general principles of organization. Some of these principles are known, but the vast majority are not." I agree.

And at the level of complex dynamic systems with self-organizing and self-referential processes we also have probabilistic theories and organic models that work well. All of these theories and models rely on characterizations of the *rates* at which causal sequences occur.

Having such rates is essential for robust modeling and prediction. And that, in turn, requires some measure of causal sequential difference: or, of what we conventionally call time.

The position taken here – which I call constructionism -- is that the major theories of external physical time suffer from a shared fundamental weakness: they treat time as something that exists on its own and as something *in which* all physical things exist, as well as something that needs a theory. Instead, I maintain, time does not need a physical theory because it is not a physical existent.[1] Indeed, that is the central ontological claim I will make about time. Rather, I hold that we need a theory of the characteristics of time in its status as a type of mapping attribution – or calibration -- of physical change, i.e., of causal sequential difference. And naturally, when we measure the extent of those sequential differences (with a clock) we go on to attribute the characteristics of the measure (time) to the differences that are measured (the processes). But doing that leads to serious confusion. Namely, although characteristics such as duration and pastness are mapped by us with clocks onto physical sequential differences, they are not inherent characteristics of those differences themselves.

The base case for holding that time is a way of measuring sequential difference, or change, is simple. First, I see no evidence that time itself is physical, i.e., that it possesses any of the properties of things in the known inventory of the physical world, . Causal sequences certainly are, on the other hand, in that inventory. So external time appears to be something else, such as a secondary property of those things that *are* in the inventory of the physical world. For example, duration – i.e., how long something exists -- might be such a

[1]Importantly, in relativity theory and its introduction of spacetime, *time* is one of four dimensions of the physical universe, the others being the three dimensions of space. I think the *temporal dimension* in spacetime – which defines each four-dimensional point as an event -- can be recast as *an event placement series*. Specifically, if we agree that time is a scalar measurement of movement, or change, as well as that conventional time-keeping devices and practices *assign* output values of a *standard of movement* (i.e., a 'good' clock) to one of the coordinate values of an event, we can find the placement series value for that event with a function that maps point-specific spatial values to sequential placement values. The solution values of that function will be the *serial placement values* of an event, which will be equivalent to *elapsed time*.

property. I maintain, however, that properties like duration are strictly derivative, relational and practice-generated constructs that range over the actual behaviors of the physical sequences measured by them. None of them are intrinsic properties of those processes and none actually inhere in the physical entities or processes to which they are attributed. As a possible secondary property, duration can be represented by a standardized clock measuring the (temporal) clock extension between two abstract points on the line of a given uniform process. Such temporal extension will be the output of a clock measuring and mapping protocol that assigns a extensional value (duration) to a comparator process or event.

The principal theoretical underpinning for time as a physical phenomenon comes from thermodynamics, the theory of heat and heat transfer[2]. Heat transfer is the fundamental physical phenomenon that distinguishes past from future events because it is directional, passing from hotter to colder or higher energy to lower energy states. Crucially, this directionality is an inherent property of the physical states undergoing change. And that change and directionality can be calibrated with a clock. But that directionality is not, however, a property of the calibration itself.

In summary, we calibrate the causal sequential paths of matter, energy and particular things with conventional time. As well as the many complex organic systems with self-referential operant and centralized neural processes that are internally calibrated and regulated by nested systems. These systems have cycles, thresholds, boundaries, frequencies, and cadences that are causally and organizationally co-dependent and that function within specific ranges and tolerances. Self-referentially, they 'tick'.

In closing, I want to thank my editor, Roy C. Dicks, whose generous support, guidance and oversight have been indispensable to this project.

Raleigh, North Carolina
April 15, 2024

[2]The equations of classical and quantum mechanics hold tenselessly, i.e., they have no intrinsic temporal directionality. In quantum theory (not addressed here) this is known as charge, parity and time-reversal (CPT) symmetry.

ON TIME

SHORT ESSAYS AND VERSE IN THE METAPHYSICS OF TIME

Metaphysics

The branch of philosophy that considers the fundamental nature of being, including foundational concepts and principles of existence, time, space, identity, change, necessity, possibility and causation.

THE METAPHYSICS OF TIME

The framework for much recent philosophical work on time was set in 1908 by John Ellis McTaggart. McTaggart was heavily influenced by Spinoza and Hegel and denied the reality of time:

*"For the sake of brevity, I shall speak of the series of positions running from the far past through the near past to the present, and then from the present to the near future and the far future, as the **A series**. The series of positions which runs from earlier to later I shall call the **B series**. The contents of a position in time are called events. The contents of a single position are admitted to be properly called a plurality of events. (I believe, however, that they can as truly, though not more truly, be called a single event. This view is not universally accepted, and it is not necessary for my argument.) A position in time is called a moment. The first question which we must consider is whether it is essential to the reality of time that its events should form an A series as well as a B series. And it is clear, to begin with, that we never observe time except as forming both these series. We perceive events in time as being present, and those are the only events which we perceive directly. And all other events in time which, by memory or inference, we believe to be real, are regarded as past or future -- those earlier than the present being past, and those later than the present being future. Thus, the events of time, as observed by us, form an A series as well as a B series."* J. Ellis McTaggart, "The Unreality of Time", *Mind*, 1908, 17 (68), p. 458.

Relying on these distinctions McTaggart developed a highly controversial argument.

1. Time is real only if real change occurs.
2. Real change occurs only if the A-series exists.
3. The A-series does not exist (because it entails a contradiction).
4. Therefore, time is not real.

"Thus, according to McTaggart, the source of time and change must be found in the A-series. But the A-series implies a vicious regress. Any event must have all three properties, pastness, presentness and futurity, but this is a contradiction. The only way out of the contradiction is to say that the event is past, present and future at different times; but the same question arises about the temporal instants themselves, which would force us to appeal to a further time series to avoid the contradiction." Kris McDaniel, "John M. E. McTaggart", *The Encyclopedia of Philosophy*, 2020.

Front Notes: To Begin: Some Theories of Time

The nature and structure of time remains a subject of great complexity, concern and controversy. It has a very long history in Western and Eastern thought. Since the work of ancient Greek philosophers and the modern work of Hume, Hegel, Russell, Minkowski and Reichenbach many theories have been propounded. On the whole this work has been of exceptional quality, imagination and impact. Many theorists – analytical philosophers, phenomenologists, theoretical physicists, clinicians, brain and cognitive scientists, and information theorists – have developed and contributed to a large body of work intended to ground and elaborate our understanding of time and how it is experienced. Beginning with the Sophists, Heraclitus, and Aristotle the analysis of time has preoccupied the work of Aquinas, Galileo, Newton, Leibniz, Hegel, Einstein, McTaggart, Russell, Whitehead, Husserl, Sartre and, more recently, Feynman, Penrose, Lucas, Sider, Dainton, Barbour, McDaniel, Albert, Mortensen, Smolin, Arthur and Greene. Theories receiving the most attention since acceptance of the theories of relativity include temporal realism, four-dimensionlism (the block universe theory/eternalism), the growing block theory, the moving spotlight theory, varieties of presentism and illusionism. The theory advanced here I call constructionism.

To Begin: Some Theories of Time

First, if something 'is so' only abstractly,
in the timeless or omni-temporal sense
of a logical or universal truth,
there is no particular time at which it is.

And if we take a natural stance on the physical world,
saying all present events -- and only those -- exist,
and that no past event, once past,
nor any future event not yet can be,
we are presentists.

Or we may say events accumulate,
as prior events recede from present ones:
both events are real, but differently so;
and future events – as future -- are not.
Saying that makes us possibilists, or growing block theorists.

We may even say that all events are on an equal footing:
that their past, present and future states are just values
in a constant four-dimensional (spacetime) coordinate system.
Saying that makes us block theorists, or eternalists.

Further, we may recast the block theory dynamically,
holding that present temporary entities and events
have a special quality of 'presentness'
(even though no entities or events *come into* existence).
That is, the present is ontologically more dense.
Saying that makes us moving spotlight theorists.

And, we may say that world time does not exist;
that it is either an illusion or only a calibration
of causal sequence difference (change).
Saying that would make us skeptics, or maybe constructionists.

With certainty, however, the theory of time evolves.

Front Notes: Causation, Entropy and Time

Among the most fundamental questions about time are its metaphysical status – the sort of being that it has – and its direction. Its fundamental status includes questions about its constitution – is it a primitive of reality that cannot be reduced to any other thing or is it composed of parts with properties? It seems clear that progress has been made, particularly since the advent of relativity and more recently in the collaborative work of philosophers and theoretical physicists. The position advanced here is that relativity is well-supported but block theories of time based on relativity are not; that time, as an apparent physical dimension, is instead a construct without independent ontological status, that time is a calibration of causal paths governed by entropy, and that not even a relativized and diffused presentism -- with extended present events indexed by actual and possible observers -- is defensible.

"There is a detectable difference between the past and the future only when there is a flow of heat. . .The flow of time emerges . . in the context of statistics and thermodynamics. This may hold the key to the enigma of time." Carlo Rovelli, *Seven Brief Lessons of Physics*, New York: Riverhead Books, 2014, p. 62.

"I argue that events exist neither timelessly nor at all times." Richard T.W. Arthur, *The Reality of Time Flow*, Springer Nature, Switzerland, 2019, p. 4.

"Only timelike intervals have endpoints that are causally related. Thus, the fundamental criterion for this partition of intervals in the space-time continuum is derived from considerations of causality." Henry Mehlberg & Robert S. Cohen, "The Causal Nature of Time", *Time, Causality, and the Quantum Theory*, Boston, D. Reidel, 1980, 243-249.

Causation, Entropy and Time

"We possess a time order only because the structure of the causal chains admits such an order. Time is the order type of causal chains." Hans Reichenbach, *Axiomatization of the Theory of Relativity*, Berkley and Los Angeles, University of California Press, 1969.

"Light signals are carriers of information and crucially have thermodynamic aspects due to the irreversible nature of the emission process. . . Reichenbach's 'causal' theory is in fact an entropic theory of time order and consistent with his entropic theory of the arrow of time." Freidel Weinert, *Reichenbach's 'Causal' Theory of Time: A Reassessment*, Springer Pre-print, Bradford, 2023, p. 2.

"Time is related to change, and through change to the things that change and the space in which they change. But quite apart from change, time is related to consciousness, and hence with persons." J.R. Lucas, *A Treatise on Time and Space*, Routledge, New York, 1973, p. 5.

Things change.
And change, fundamentally,
is causal sequential difference.
Abstract objects can sequence arbitrarily,
proceeding this way, then that.
Energy-mass objects cannot,
their sequences proceed irreversibly,
from ordered to less ordered states.
That is entropy.
It is fundamental. It is relentless.
It is represented in physical law[1]
and can be predicted,
its forward effects manifest as
this open interval, the next-open interval, the next- . . .
calibrated in arbitrary *temporal sequences* of
just then, now (this open interval), the next-open interval . . .
or, of non-durational abstractions: (t_1, t_2, t_3, t_4 . . .).

That is the argument.
Time -- in the physical world -- is a calibration of entropic change.

[1]The second law of thermodynamics.

Front Notes: Demoting Time

Two deeply entangled representations of time must be distinguished: subjectively lived, or experienced time, and objectively physical or external time. Accomplishing this is difficult because the *act* of considering this distinction is *experienced as an event*. There is no question that human experience, and very likely the experience of all sentient beings, is fundamentally temporal. Our neural architecture and the biological systems regulated by that architecture are temporal at every operational level *in the sense that the physical processes of those systems are co-calibrated* to function homeostatically and synchronously in a body-world environment. Nonetheless, it is held here that external (physical, world) time is a construction and ontologically derivative -- as a measure of causal sequential difference -- and is neither metaphysically primitive nor irreducible. When we calibrate the duration of something we hold an arbitrary yet reliable standard of change (e.g., a 'good clock') 'alongside' some causal sequence to produce a measurement: i.e., we measure the *time* that has elapsed. In this way time is the constructed product of measuring a target process with a standardized process. It is relational. And we can apply this process in any inertial frame of reference.

"*. . . a defender of absolute time thinks there is such a thing as time itself. It exists substantially without anything else. Relationist metaphysics rejects this. Instead of there being time itself, relationism maintains that physical events and notably their relations are fundamental for the existence of time*." Matias Slavov, *Relational Passage of Time*, London and New York, 2023, Routledge.

Demoting Time

"In this new picture, history is not something that happens in time but a path through a landscape. . . I use the word path very often in the generalized sense of a continuous series of configurations taken by some system. . .Understood in this sense paths are possible histories. There is no time in this picture. . .Time is nothing but change." Jullian Barbour, *The End of Time*, New York, Oxford University Press, 1999, pp. 43 – 44.

Barbourism

The metaphysical circle is tight:
no change, it seems, without time;
no time, it seems, without change.

Change comes as *from-to*,
as sequential difference in the world.
It is real. It occurs. It is not simple.
It has stages that overlap.
It is an ontological hybrid.
It seems intrinsically temporal.

And time? This is harder.
Perhaps time is basic, a primitive,
a 'there' even if no other thing exists (a deep implausibility).
Or a precondition for any non-contradictory world
where A's and not-A's cannot co-exist.

Or we may think time is an error, an illusion,
a misinterpretation of location in world topology.
Or even that it is somewhat real, but only derivatively,
'there' but not metaphysically basic,
a relation (only) between events, changes in real things,
a metric of sequence, causation and entropic increase.

The latter seems better.
That time is a derivative of change, an attribution, a construction,
a convention for calibrating continuous difference.
Only that and nothing more.

Front Notes: Calibrating What Happens

The central position taken here is that external or physical time is a product of the calibration of change -- where 'calibration' is understood as a standard-giving event and 'change' is understood as the target comparator event of physical sequential difference -- and that the method of calibration we use, while entirely conventional, is dependent on the real properties of those sequences. The challenge is to avoid confusing the *real* properties of sequential differences with the properties of the *methods* we use to measure them.

Agreeing that time is a derivative of change and not a broad feature of the world, Christopher Tyler nonetheless maintains its existence at the locally infinitesimal level. I do not think this works for three key reasons: it circularly appeals to a *rate* of change in accounting for time, it still affirms temporal independence and it implausibly precludes any recognizable notion of temporal extension (duration) by appealing to infinitesimals. Appealing to infinitesimals shrinks any interval of change to nearly nothing. Yet whether larger temporal intervals are needed to account for change is a central philosophical question.

"The nature of time is intimately bound up with the nature of energy propagation, which has a long history of its philosophical understanding. Here I propose a new post-Einsteinian view of the nature of time, conceptualized as the outcome of the pure unidimensional rate of change of a process through the infinitesimal operator of differential equations. In this view, time is a local property that is generated by every individual process in the Universe rather than a fundamental dimension in which processes operate." Christopher W. Tyler, "The Fundamental Nature of Time," *Journal of Research in Philosophy and History*, 2020, 3 (1), p. 1.

Calibrating What Happens

"Essentially, then, we measure time by having rules enabling us to pick out pairs of instants, and to say that the interval between one pair is equal to, greater than, twice as great as the interval between another pair. . . Once we decide to measure time by external events and observable processes, we are led to think of it as the numerical aspect of process and the dimension of change, and to impose on it – and hence also on space – certain profound and philosophically puzzling properties." J. R. Lucas, *A Treatise on Time and Space*, London and New York: Routledge, 1973, p. 64.

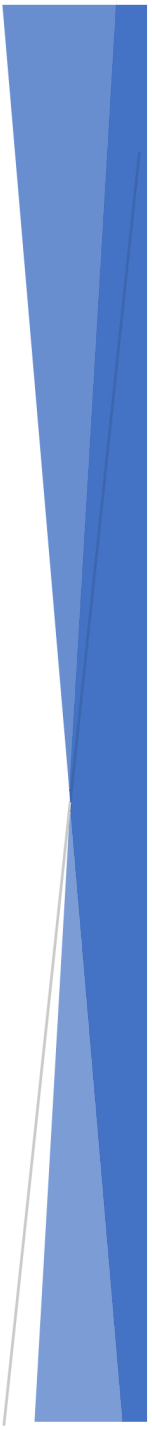
Minding the Trap

We fall into this trap,
quite easily,
when we talk about time.
We want to say it is *something*,
on its own,
something external to us,
something with peculiar properties,
something we live with
that flows in and around us, inexorably.

But that confuses the description
with what is described.
Time is the description,
a way of talking about the
causal sequential extension of something.
But it is not *what* is described.
Time *calibrates* some of the properties
of external things, like flow
and direction and irreversibility.
But it does not itself flow or have direction.
Because it is *dependent* on sequential extension.
Its properties are derivative and conventional.
And, for us, they are largely local.

Time is not a thing like other things.

Front Notes: The Problem with Change



Change is a vexing topic. At first glance, it seems clear that all change consists in *something* changing. In turn, this seems to require that such a thing, *as a thing*, persist in some way *through* change. Immediately, we confront a puzzle: in what manner can a changing thing be said to remain the same thing that it is? Must some property of a changing thing remain constant as other properties vary; or must a thing have temporal as well as spatial parts to accommodate change? And, if so, how can temporal parts constitute the whole that is the changing thing?

In classical physics change, or movement, is understood as a difference in position with respect to time. In the theory of relativity time itself must change based on the speed of a body in one reference frame moving relative to an observer in another. And in quantum physics, change is a temporary random fluctuation is the energy of a point in space.

"If a changing thing has different and incompatible properties then a contradiction is threatened. The obvious move to make when confronted with the fact that things change, is to say with Kant (1781) that they change in relation to time, which avoids the inconsistency. But then another problem emerges. In what sense can one thing persist through change? Identity across time and space is the mark of universals, but we also account particulars such as billiard balls and persons as having self-identity across time. . . Still, it emerges that the connection between change and inconsistency is deep, and that the case for inconsistencies in motion and other change is surprisingly robust" Chris Mortensen, "Change and Inconsistency," *The Encyclopedia of Philosophy*, Stanford: 2020.

The Problem with Change

A central question about change is whether there can be time without change. The position defended here is that there cannot be time without change just because time *is* the calibration of change. Robert Le Poidevin opposes this position:

"Consider, then, a world containing a finite number of objects in which one of them, y, exists in an unchanging state. Given that this is a changing world, there can be no objection to treating y as existing in a state of temporal changelessness. Now, according to the picture presented here, y's state of changelessness exhibits an internal causal structure, a causal structure that is independent of the other objects. We now run the subtraction argument of the first step, to reach a world in which only y exists. Since the internal causal structure that y's state of changelessness exhibited in worlds containing other objects is intrinsic to that object, subtracting those other objects cannot make it the case that y lacks that structure. Consequently, the final step of the argument presents us with a world containing just y and in which y exists in a state of changelessness that exhibits a causal structure. But that causal structure is sufficient to sustain a temporal structure, since it is both ordered and directed. So this is a world in which there is a period of time without change." Robert Le Poidevin, "Time without Change," *American Philosophical Quarterly*, 2010, 7 (2), pp. 177 -178.

Le Poidevin's approach to showing there can be time without change relies on the so-called 'subtraction argument' where, one-by-one, we subtract co-existent objects which *are changing* from an imagined world so that we are left with one object that is, singularly and intrinsically, not changing. Since such an object can be conceived as existing only if it is intrinsically causally structured to not change, and since such a causal structure would be sufficient to sustain a temporal structure that is both ordered and directed, we can say that, in the instance of this object, we have time without change. While impressive, this argument is unpersuasive in its reliance on an imagined form of immanent causation that, presumably, instantiates an equally immanent direction of time. I will go with no time without change.

Front Notes: Relativity: Motion Makes the Measure I

In 1887 Albert Michelson and Edward Morley established that light waves were not moving through a medium that was referred to as the aether. This unexpected result deeply undermined the assumption that all waves must be transmitted through a medium and, with it, some of the central foundations of physics.

Later in 1905 in a small paper modestly titled "On the Electrodynamics of Moving Bodies," Albert Einstein proposed the Principle of Relativity according to which the laws of physics are the same in all uniformly moving frames of reference and that the speed of light, *c*, is also the same in all uniformly moving reference frames. With these stipulations and his derivation of the Lorentz transformation Einstein showed that physical length is contracted and that time is dilated (lengthened) when observers are in motion relative to each other. This showed that neither time nor length could continue to be regarded as absolutes. In the theory advanced here I propose that time, as the fourth dimension of spacetime in the theories of relativity, functions as a *displacement variable* that captures movement, and change generally, in three-dimensional space.

"It was essential, he [Einstein] states, to realize what the meaning of coordinates in physics is: they are nothing but the outcomes of length and time measurements by means of rods, clocks and light signals." Dennis Diekes, "Space, Time and Coordinates in a Rotating World." *Relativity in Rotating Frames*. Springer, 2010, pp. 29 – 42.

Relativity: Motion Makes the Measure I

"*Every reference-body (co-ordinate system) has its own particular time; unless we are told the reference-body to which the statement of time refers, there is no meaning in a statement of the time of an event.*" Albert Einstein, *Relativity*, New York, Three Rivers Press, 1916, p. 31.

Scenario A. Okay, I have a light box on the railway embankment.
A single pulse of light (traveling at constant speed)
makes a vertical round-trip in the box:
one meter to up to the top
and one meter down to the bottom.
Two meters in all.
My clock ticks 0.00000000667128 seconds.

Scenario B. Now, I board a train with the light box.
The train reaches a constant forward velocity.
A single pulse of light makes a vertical round-trip:
one meter up to the top
and one meter down to the bottom.
Two meters in all.
My clock ticks 0.00000000667128 seconds.

Scenario C. I board the train again with the light box,
with an observer remaining on the embankment.
The train departs and, for the observer,
the box moves away with the train
and the light pulse travels sideways-up, then
sideways-down, on an angular, not vertical, path.
For the observer the pulse goes farther,
and takes longer, to reach the bottom of the box.
Same box, same light pulse, different perspective.
Time, oddly, is relative to a frame of reference.
And our frames have moved relative to each other.
The other essentials have remained the same.[1]

[1] Time dilation solution with the Lorentz Transformation: $t' = t \times \sqrt{(1 - v^2)}$ where v is the ratio of relative velocity to the speed of light.

Front Notes: Relativity: Motion Makes the Measure II

The theory of special relativity established that time is dilated (relatively) when clocks move relatively to each other, i.e., in different inertial reference frames. Here is Arthur Lovejoy's colorful and enduring 1931 description of time dilation:

"Once upon a proper time there were, or let us rather say, in the indefinite present, 'there are' - since, after all, these events have not yet really happened - twin brothers, Peter and Paul. Peter is a home-keeping youth, but Paul has the soul of an adventurer and busies himself with the construction of a machine for flying through space at an enormous speed. When he and Peter are twenty years of age he completes this contrivance and sets forth upon his journey. Attaining almost at once a velocity amounting to a large fraction of that of light, he continues his celestial joyride at a uniform velocity, moving always in a straight line. At the end of a year, as shown by the clocks he has carried with him, he is able to reverse his motion and return to the earth at the same speed. Landing in his hometown, he discovers that in it decades have passed and that his stay-at-home twin is now far older than himself. Nor would this be a conventional difference of calendars, a mere matter of bookkeeping. Paul will - such, in a relativistic universe, we are told, are the hygienic benefits of a fast life - be physiologically younger than Peter; indeed, if his speed was less by only l/20000 than that of light, he will, returning as a youth of twenty-two, find that 200 years have elapsed on the earth, and consequently that his twin brother has long since died of the infirmities of age." Arthur O. Lovejoy, "The Time-Retarding Journey," *The Philosophical Review,* Vol. 40 (1), 1931, p.p. 48-49.

Relativity: Motion Makes the Measure II

"*Measures of space, as well as of time, are different in different reference frames*." Richard Wolfson, *Simply Einstein: Relativity Demystified*, New York and London: W. W. Norton & Company, 2003, p. 115.

Into a Different Future

I find a slight unease in knowing
I have theoretical options.
I could go away for a while,
say, for one year,
at the speed of a rocket,
returning less aged
than those older here on earth,
less aged, that is, by my rocket clock
than they will be by theirs.

And this will be a real effect:
my hair may gray a little
but not as much as theirs
because my causal path –
accelerating into and through space --
will be different:
relative to the speed of light
(constant and universal we think)
I will travel faster through space.
And so, I and my rocket clock
will not 'tick' as much
(traveling from home and back again)
as my kitchen clock will tick.
I will return to a home world, and time,
far ahead of rocket time.

So bizarre it seems, this effect.
We want to say our ages *are* our ages,
true everywhere.
But they are not.

Front Notes: What Lies Behind Does. What Lies Ahead Does Not.

Clearly time, especially a temporal state referred to as 'the present,' 'the past' or 'the future,' remains a subject of great controversy. Some theorists take a position that treats space and time interchangeably in a co-ordinate system where no place or time is privileged. For these block theorists all events (times) exist, in some sense, *tenselessly*. Support for this view has declined as efforts to deny the existence of future events have been mounted while retaining some ontological status for past events. These growing block theorists hold that past and present events accumulate while future events do not exist. Presentists, rejecting both approaches, argue that only present events (perhaps broadly taken) ever exist are actual in any full-blooded ontological sense, although they may struggle to defend a coherent conception of the present that is greater than a non-durational instant. Many versions of the metaphysics of intervals in an extended present have been proposed. And some theorists, like Julian Barbour, maintain that any notion of external or physical time is not real. The position taken here is that external time is not real *per se*, that it is only a construction over calibrations of the sequential differences along causal paths, and that *only such paths* are metaphysically real.

"In addition to our being in time itself and its passing, . it seems at least possible that ideas of the physical are a means of defining space and time rather than the other way on." Ted Honderich, *Actual Consciousness*, Oxford: Oxford University Press, 2014, p. 167.

What Lies Behind, Does. What Lies Ahead, Does Not.

"There is no unique actual future; as a consequence, there is no fact of the matter concerning whether the event will or will not occur." Patrick Todd, *The Open Future: Why Future Contingents are All False*, Oxford, Oxford University Press, 2021, p. 83.

First, 'The Past'.
It does not exist. Not as a thing.
Prior events are simply prior.
They did happen but no longer do.
Caesar crossed the Rubicon.
This, we think, is an uncontestable fact.
Yet what makes it so?
Well, Caesar *did* cross the Rubicon.
That is what makes it a fact that Caesar crossed the Rubicon.
The causal path from Caesar to the at-now
worldline would be different had he not.
Prior and present events are causally composite.
Yet no present event (fact) can unmake a prior one.
Quantum randomicity and entropic irreversibility ensure it.

Second, 'The Future'.[1]
It does not exist, either. Not as a thing.
There are only causal paths with physical noise.
Future 'events' *as future* cannot count as events,
and future-tensed statements about them cannot be true.
All propositions they (appear to) instantiate are false
because they have no truth-makers.
Or -- we might say -- they instantiate predictions
(not propositions) that turn out to be good or not.

'The Future' isn't there. There are only causal paths with noise.

[1] I assume indeterminism, or dispositionalism, where some effects of causes are only tendencies or probabilities rather than chained necessities. Also, a relativistic version of interval presentism seems workable as long as it is taken as *an analysis* of our construction of physical (external) time. Crucially, there is no problem of future contingents. Last, classic determinism is a deeply counter-intuitive theory entailing that any two of its models will have instantaneous slices that are isomorphic so that their final time segments will also be isomorphic. This idealized attempt to defend necessitarian forms of determinism weakens it as an effective explanatory principle.

Front Notes: Presently Prior I

Following is additional support for the positions taken here regarding relations between 'prior' (construed broadly) and 'present' (construed broadly) events. Consider this succinct statement by Avril Styrman:

"The causal explanation strengthens the pro-passage interpretation over the no-passage interpretation. It rests on the idea that the laws of physics entail the causal succession of events, that is, a dynamic process where one event is transitioned into another event. This allows defining the passage of time as the causal succession of events, and the direction of time as the direction of their causal succession." Avril Styrman, *"The Passage of Time as Causal Succession of Events*," The Journal of Philosophy, Vol. 120, Issue 12, 2023, p. 697.

Lee Smolin (cf. *Time Reborn*) draws a different conclusion from the same evidence, holding that time exists even though *there are only processes that follow one another causally*. I find this position inconsistent.

"A causal universe is not a series of stills, following on, one after the other. There is time, but there is not really a notion of a moment of time. There are only processes that follow one another by causal necessity." Lee Smolin, *Three Roads to Quantum Gravity*, New York, Basic Books, 2001, p. 55.

"…we must distinguish between a moment, t, and the event of the moment's being present with respect to a given perspective and, above all, between the event of the moment's being present with respect to a given perspective and the event of the moment's being present*. The latter, of course, is the essential feature of a temporal picture of the world."* Wilfred Sellars, "Time and the World Order," 1962, p. 577.

Presently Prior I

"Von Wright proposed . . . that time is regarded as structured as nested intervals rather than an assemblage of atomic point-instants. . . Now in the ontology of intervals the most one can say is that a proposition holds somewhere in the interval, with the limiting case that it holds throughout the interval." Chris Mortensen, *Change and Inconsistency*, Stanford, *The Stanford Encyclopedia of Philosophy*, 2020.

"If Compound Presentism is true, the sum total of reality is different as of different times, and the sum totals at adjacent times partially overlap, but this pattern is symmetrical in both temporal directions. . . Consequently, any apparent direction within time must be a product of the asymmetries that exist among the contents of time." Barry Dainton, *Time and Space*, Second Edition, Montreal & Kingston, McGill-Queen's University Press, 2010, p. 101.

A Thing in the World

A thing in the world
is temporally ambiguous:
its present an accomplishment of its past,
its past an accomplishment of before,
its future an accomplishment of its now;
its presence a product and constraint,
its existence a history in causal space.

Though past, the past[1] (what came before) is not inert.
It is the causal path to and through any present[1],
the configurative residue of prior events.
It marks what has been
from what is occurring.
It conditions the forward now.
It is a predicate.
It sets the limits of possibility.

A thing in the world is ambiguous:
it is a differential arc between
ontological horizons.
It is causally on the way.
And it is always presently prior.

[1] 'Present' and 'future' are here equivalent to 'prior', 'now', and 'next'.

Front Notes: Presently Prior II

Conscious, unconscious, and active memory processes (in their many operant modalities) are deeply implicated in the experience of time:

"The rapid reentrant interactions within the dynamic core thus give rise to a sort of temporally ongoing 'bootstrap', according to which changes in the pattern of firing of neuronal groups involved in perceptual categorization can select one out of scores of specific activity patterns involving the entire core – an entire memory repertoire. This selection generates a large amount of information over a short time, hence creating a scene in the remembered present."
Gerald M. Edelman and Giulio Tononi, *A Universe of Consciousness: How Matter Becomes Imagination,* Basic Books, New York, 2000, p. 173.

"The content of the memory is not identical with the episode remembered but, rather, consists in this episode transformed – or mutated – in certain ways. These transformations are effected by the act of remembering." Mark Rowlands, *Memory and the Self*, New York, Oxford University Press, 2017, p. 169.

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Presently Prior II

"*The brain must select from all the information it constantly receives, and it does so through a process of filtering and concentration that we call 'attention' [which] requires the use of short-term memory, which has a limited capacity. The brain is [then] able to reach the next stage: perception [which is] is a creative process*." Jordi Cami and Luis M. Martinez, *The Illusionist Brain*, Princeton, Princeton University Press, 2022, p. 34.

"Each phase of a typical stream of consciousness is phenomenally bonded to its immediate predecessor and successor: there is a direct experiential link between adjacent co-streamal phases." Barry Dainton, *Time and Space*, Second Edition, Montreal & Kingston, McGill-Queen's University Press, 2010, p. 97.

Curating Ourselves

We curate ourselves on memory platforms:
sensory, short, working, explicit, implicit, declarative,
procedural, somatic, semantic and episodic.
Their states and run rates
rendering us functional, sensible and cognitive
in exquisitely consonant lived time.
We are their temporal composites.

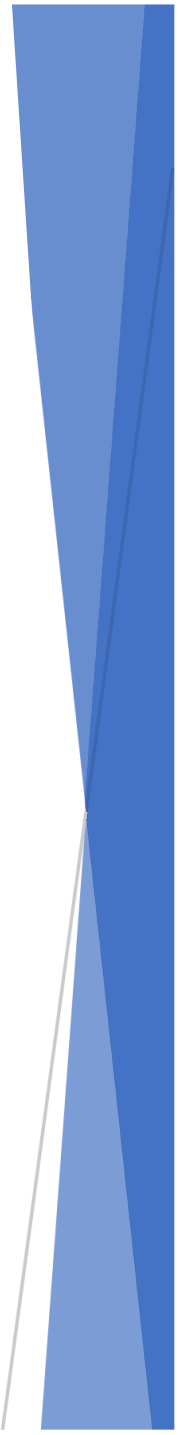
They interleave our becoming and being,
microseconds before perception.
They compress, interpolate and synthesize
the small construction of now
from the near prior.

It's mostly out of sight, underneath,
being us somehow, but not quite,
the entrained clockworks running inside.

Front Notes: In the Neighborhood of Zero

Much of advanced mathematics and physics relies on continuous functions. Their products are continuous in that they are not mere summations of discrete values and very small changes in their values can be assured by sufficiently small changes in their arguments (an argument of a mathematical function is a value provided to obtain a result of that function). Summations of discrete values are inherently discontinuous in that there are other values 'between' arbitrarily defined discrete values. Summations are 'lumpy', each discrete value constituting a boundary with its neighbor. If, for example, we use only discrete values to calculate the area under a curve we get an unsatisfactory estimate.

To avoid this outcome, it is necessary to assume the function is continuous and that there are no jumps or gaps between the values that are used in such a calculation. And, to do that, theorists employ the notion of a *limit* where the value of a variable approaches some terminal value; which might be infinity. When the limit is set to infinity, the value of the function asymptotically approaches another value, perhaps zero, which, for computational purposes, it is assumed to reach. In this way instants – zero units of time – have been posited as the effective results of temporal functions in some theories of time. As non-dimensional 'units' they tag time values (e.g., t_1, t_2, t_3, t_4 . . .) onto curves and functions assumed to be continuous without creating defined intervals and boundaries that would make them discontinuous. Doing this avoids giving a presumably continuous existent – time -- discrete parts. However, such 'tags' are neither in nor proper parts of time.



In the Neighborhood of Zero

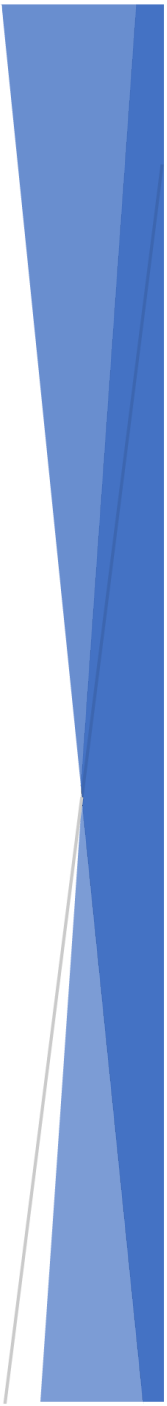
"The concept of the instantaneous rate of change of some physical quantity, position most strikingly, poses a significant philosophical dilemma. . . We will conclude that there are two distinct conceptions of a temporal instant: (i) instants conceived as fundamentally distinct zero-duration temporal atoms and (ii) instants conceived as the boundary of, or between, temporally extended durations." James Harrington, *Instants and Instantaneous Velocity*, Loyola University-Chicago, 2008, p. 1.

The Instantaneous and The Infinitesimal

A tennis ball whips with backspin,
rises, then drops over the net.
A sprinter leans impossibly,
first across the tape.
A rocket rises imperceptibly,
then races into space as a bullet.
The velocity of each changing at changing rates.
Yet *exactly* where -- and when -- are they changing?
Perhaps tiny differences can approximate change.
Or perhaps we can do better, with instants:
points 'in' time at no time at all.
And here, of course, we find a puzzle:
can there be change in no place and at no time?
Certainly not if change is physical sequential difference,
and not if any physical thing must be some place.

So – unavoidably – we go for a fudge:
we approximate zero at the near-zero:
micro-positions can be found with tangents on curves.
And micro curve segments can be found with limits.
They can get us in the neighborhood of zero,
In the neighborhood of null points and null instants.
And with that we can get "instantaneous" velocities.
But not velocities without change or duration.
They cannot be.
Yet we get close enough,
at the inconsequentially small,
in the neighborhood of zero.

Front Notes: Encoding the Causal Path



Prior (past) events are implicated in now (present) events. This is the central notion of causality. The extent of this implication is a function of an array of convergent causal properties: granularity (fine-grained, immediate, and parent-child relations appear more influential), control, linearity, persistence (the value of the causal decay function), and, where events are human actions, narrative representation (lore).

If the conventional notion of physical (external) time is dependent on an 'ideal' or 'good' clock (i.e., one that is physically invariant), and if the causal processes calibrated by such a clock often occur non-linearly, we should expect those calibrations to be non-linear as well. For example, if one frame of reference is accelerating relative to another, the representation of time of the observed frame will be non-linear in the frame of the observer. This topological feature of external time can be overlooked when it is practical to characterize it as linear. Acceleration as a source of non-linearity is well-understood. Yet temporal non-linearity can also arise from phenomena such as causal stasis (static countervailing causes), conjoint causality, causal randomness, absence of defined causal antecedents, and gravitational bending.

Encoding the Causal Path

*"If we subscribe to the factual inheritance principle then since **P** [a proposition] is true of t_2, and t_2 coexists with t_3 in a single extended present, then **P** must also be true of t_3 even though the relevant truth makers [for **P**] are no longer real as of this time. The factual inheritance principle allows truths (or facts) about earlier times to accumulate at later times, and thus be transmitted over time."* Barry Dainton, *Time and Space*, Second Edition, Montreal & Kingston, McGill-Queen's University Press, 2010, p. 100.

"Given PEP [presentist existential pluralism], one might worry about what grounds the truth that a past object once was present, or the putative truth that every present object will be past. The former worry is easily quieted: the past existence of past objects suffices to ground the claim that they once were present." Kris McDaniel, *The Fragmentation of Being,* Oxford, Oxford University Press, 2017, p. 96.

The Factual Inheritance Principle

There are no instants,
no times without duration.
Real moments come as their causes come:
imperceptibly or in phases or in chunks
or careening out from their antecedents
as stabilizers shift, fail and reset.
This we calibrate as time.

What comes before encodes each now, and next.
It carries content and possibility
to its causal heirs, the inheritance,
residual in each extended present.
It comes as states: serial, conjoint and transitional,
emergent, determinate, random and degenerate.
It has no proper parts, no pieces.
It is dynamic, a causal legacy.
This we calibrate as time and history.

What comes before comes and goes,
existent once, residual later
in the causal enormity of its legacy,
diminishing on the entropic path forward.
This we calibrate as time and history.

Front Notes: Causal Chains and Loops

A causal chain is taken to be a sequence of sufficiency relations between objects -- or events -- and the consequential events they instantiate that may produce, sustain, or degrade the sequences of a given chain or those of other chains. It is assumed that such chains may be symmetric (e.g., between parts) as well as asymmetric (e.g., between complex wholes), causally transitive if necessary, and have branches. Chains are assumed to constitute a principal physical feature of causal paths through spacetime and to exhibit temporal inheritance characteristics including dispositions, properties, dependencies that overlap stages and phases within each chain. It is also posited that causal chains may have topologies which include attractors and causal loops where feedforward and feedback processes produce complex systems. (cf. Anjum and Mumford, 2018)

"There are two different kinds of action here: the symmetric interaction of the parts are examples of transitive action, whereas the asymmetric evolution of the complex system is an example of developmental action. In transitive action, two different objects act on each other by means of a causal relation in such a way that both objects are changed. In developmental action, a system evolves through time, where the changes are not due to things outside of the system, but due to the interactions of the parts of the system." Andrew Newman, "A Causal Ontology of Objects, Relations and Various Kinds of Action," *Synthese*, 2022, p. 308 – 309.

"We possess a time order only because the structure of the causal chains admits such an order. Time is the order type of causal chains." Hans Reichenbach (1969).

Causal Chains and Loops

"The inferences from experiences to the physical world, can, I think, all be justified by the assumption that there are causal chains, each member of which is a complex structure ordered by the spatio-temporal relation of compresence (or of continguity), that all the members of such a chain are similar in structure; that each member is connected to each other member by a series of contiguous structures; and that when a number of similar structures are found to be grouped about a center earlier in time than any of them, it is probable that they all have their causal origin in a complex event which is at that center and has a structure similar to the structure of the observed events." Bertrand Russell, *Human Knowledge*, New York, Simon and Schuster, 1948, p. 228.

Every event interval has antecedents.
It is a descendant. It comes from something,
even if that something
is remote in space and time,
or lies within a causally closed loop.
It has structure. It is embedded and extended.
It may persist. It may decay.
And it will contend with other events.

Every event is the causal product
of other events: some persisting, some not,
some with causal reach, some not,
some creating form, some corrupting it.
What is, is heir to what came before.
And each interval of 'now', each present,
comes with observation, or its possibility,
in unbounded spacetime.
There is no privileged place or present.

On each relativistic worldline
prior events configure[1] the possible
and 'the present' -- as 'the present'
configures[1] the possible and 'the future'.

[1]Tenselessly. Note: some causes are necessary for their effects; yet others are only sufficient. Further, some causes and effects occur conditionally and contingently.

Front Notes: The Same and Not: The Persistence of Things

The problem of persistence through change, and time, is central to ontology and metaphysics generally. Many of the central problems of philosophy involve this issue. Fundamentally, the question is this: "how does a particular thing remain the thing that it is through change?" Attempts to answer this question have been numerous, revolving largely around efforts to keep one characteristic constant while permitting others to vary. Attempts to define constants have appealed to descriptors such as essence, intrinsicality, substance, substrate, universals, and primary properties while attempts to define variables have appealed to accidental, secondary and contingent properties. The central philosophical challenge is to defend the idea that real particulars – say, *these ships* – persist *as these ships* over time. Recent attempts to do this have included perdurantism and endurantism that, arguably, treat time as an ontological property of things, saying either that a ship is the sum of its temporal parts or that it is wholly temporally present through its changes. The view taken here is that all such efforts regarding physical particulars (objects, events, persons, etc.) must fail because -- controversially -- particulars are, rather than substantive things, only bundled forms along their causal paths.

"A 'thing', or a piece of matter, is not to be regarded as a single persistent substantial entity, but as a string of events having a certain kind of causal connection with each other. This is what I call quasi-permanence." Bertrand Russell, *Human Knowledge*, New York, Simon and Schuster, 1948, p. 475.

The Same and Not: The Persistence of Things

"Something perdures if and only if it persists by having different temporal parts, or stages, at different times, though no one part of it is wholly present at more than one time; whereas it endures if and only if it persists by being wholly present at more than one time." David Lewis, *On the Plurality of Worlds*, Oxford, Blackwell, 1986, p. 202.

On Causal Paths

When we say that something
that is one thing, is then another,
we cannot mean to say it is the same
and still another
unless that thing that is the same
is but some part of it.
And if that thing that is the same
becomes yet again another
it must be said to be the same
as only part
of what was part before it.

Yet, temporal parts seem odd
in being partly so and not.
For parts have ends
and ends of parts
cannot be parts as well;
and if so not, what are they?

And so, when of some thing
we hold it is one first thing
and then another,
we should perhaps no longer say
it is a thing at all –
but rather a form, at a point,
on the causal path that made it.

But we want to speak of things as things.
And therein lies the trap.

Front Notes: Temporal Continuity

Physical (external, world) time appears continuous. If there can be gaps *in* time it seems there would be some 'state' of non-time between durations *of* time. Efforts to develop a theory of temporal continuity have been difficult, and in physics and mathematics continuity is commonly taken to be the smooth change in the bounded value of a dependent variable given a change in the value of an independent variable. Underlying these methods are assumptions about the properties of tangency, differentiation, non-extended spatial points and non-durational temporal instants. However, we quickly run into problems – such as treating a succession of instants *as constituting time* -- when these notions are applied to physical time.

"Since I have admitted that points, though divisible from one another in the sense of distinguishable (for they are distinct), are not divisible in the sense of separate (for they are joined, and occur only as points in space), I shall not be unduly " spatialising " time if I maintain that it can be treated in an analogous way, and conceived as consisting of instants. There is really no difference between the case of space and that of time, except that the elements of the latter, being instants, are successive, which means that only one of them is real at once. This peculiarity of time has the consequence that any instant or interval, looked at from the point of view of another instant or interval, is either past or future -- i.e., only was or will be real -- so that its reality is secondary to and derived from the reality of a present instant. Thus pastness and futurity are not inherent: they are expressive of a point of view. Every instant, when alone it is real, is a present. Time is real only as a series of presents." C. A. Strong, "The Continuity of Space and Time," *Mind*, 1928, 37 (148), p. 401. I do not think that serial zero-instants are what we intend to mean by 'time'.

Temporal Continuity

There are three main problems with the idea that the temporal extension of real events is continuous. First, using the real number line – which is infinitely (i.e., continuously) divisible -- to describe and analyze time accommodates efforts to mark, partialize and divide it – with instants, intervals, boundaries, parts, junctions and durations – followed by efforts to then re-constitute it as a seamlessly continuous function. But reconstituting time from parts fails as an ontological exercise. If a smooth ontological continuity will have no gaps or boundaries we cannot get such a continuity by adding-up a series of bounded temporal parts or a series of zero duration temporal parts simply because any sum of zeros will be zero.

Second, if we accept the thesis that time is a construct, a calibration of world processes, and that actual physical processes are rarely, if ever, actually uniform or continuous, then any property of continuity that we attribute to those processes will likely be a property of the attribution scheme itself, i.e., of some application of the real number line.

Third, the real number line – in its infinite divisibility – entails that there is always a next number that can be constructed from any given number -- and between any two numbers -- which is unique and distinct from all other numbers. Further, there is an infinity of real numbers with no final value; that is, numbers that are infinitely computable. The term 'continuous' signifies the mathematical possibility of finding an arbitrarily small difference between any two real numbers. In contrast, our intuitions about the continuity of external physical time suggest its uninterruptable smoothness, with no discrete parts or values. However, since real physical processes are often in fact discontinuous -- with gaps, breaks, jumps, stops and reversals – this intuition arguably derives from the continuity properties of the real number system we use to calibrate those processes. Nonetheless, continuity remains a challenged concept due to the infinite divisibility of the real number system used to represent it.

In conclusion, I regard temporal continuity to be first a property of the scale and system used to calibrate physical processes and only contingently a property of those processes themselves.

Front Notes: Constructionism: The Standpoint

Constructionism could be regarded as making very few substantive claims while assuming a merely verbal stance on the use of terms such as "the past." That response would be required if constructionism held *only* that we should replace "time" with "the calibration of causal sequential processes." However, that is not the position being advanced. Rather, constructionism holds that theories like eternalism, the growing block theory and the moving spotlight theory mistakenly maintain that terms like "the past" pick out real aspects of the world. The position taken here is that they do not. The proper referents of 'prior events' are *the properties of the extensible causal paths of those events*. That is, if such events 'are' *prior* in that they occurred *earlier* they are not thereby 'in the past'. Timelines are only abstractions; they do not confer existence on their referents. Constructionism holds that no new information or property is designated by labeling causal process segments as "in the past" or "in the future." Doing that reifies an abstraction and converts an adverbial phrase into a noun phrase. Instead, causal processes, events and their paths are the real things to be described. The calibration of their relative positions and overlaps on a timeline is a time-keeping construction; nothing more. Naturally, I consider the following claim by D.H. Mellor to be mistaken: in 1943 World War II was *not* two years *into the future* because there was no future in which it could be. *"The right way to define the present is this. In 1943 World War II stretched four years into the past and two years into the future. So, it's A-time, a six-year interval including the present moment, should, despite its length, count as present."* D. H. Mellor, *Real Time II*, London and New York: Routledge, 1998, p.9.

Constructionism: The Standpoint

The key principles and postulates assumed by this theory are:

Relativity Principle: The theories of relativity are well-established.

Entropy Principle: The direction of change and time is grounded in entropy, the second law of thermodynamics and causal irreversibility.

Spacetime Principle: Spacetime is a coordinate-defined manifold for defining location, change and the rate of change in that manifold.

Inventory Postulate: The inventory of physical things and their properties includes particles, charges, relations, polarity, gravity and all configurations of mass and energy including processes, particulars and complexes. Particulars and complexes commonly have intrinsic and extrinsic properties and are intrinsically -- though not wholly -- present throughout their histories. Extrinsic properties are commonly fused with -- yet separable from -- other extrinsic properties. This is a bundle theory of qualities, states and things.

Change Postulate: Changes in processes and particulars are grounded in the causal properties of each which are, in turn, grounded in physical regularities, probability relations and locally contingent circumstances that are not determined by causal laws.

Process Postulate: Deterministic processes are ontological particulars with intrinsic properties and identities through change. Indeterministic processes are often diffuse serial states and may or may not be particulars.

Temporal Postulate: Time is a standardized descriptor of causal sequential relations of processes, particulars and complexes.

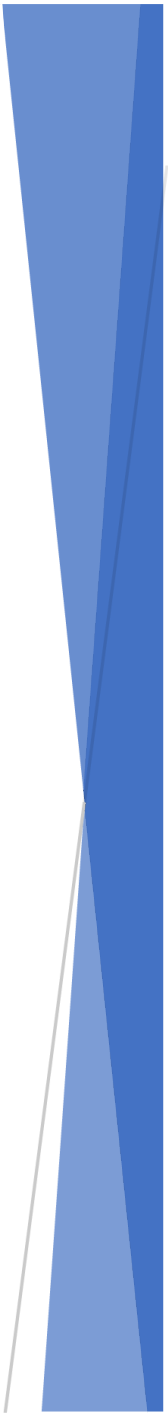
Sequential Difference Postulate: A sequential difference *just is* any difference attributable to causation (both lawlike and non-lawlike) on the assumption that there are no uncaused sequential differences.

Temporal Difference Postulate: A metric of temporal difference is a change standard that is stable, identical and replicable. Temporal difference can be referred to as duration or as temporal extension.

Duration Postulate: The duration of some event or process is the measurable difference between arbitrarily selected ‘tags’ or ‘points’ on its causal sequential path.

Front Notes: Constructionism: Some Implications

Among the many implications of the theory of constructionism is the apparent need to show how a temporal construction system can be coherent and effective in describing and ordering external physical processes. First, a successful system cannot be completely arbitrary: where real processes are sequential and directional those process properties must be represented in the time-keeping system. Second, where processes are not sequential, as with random movement and other non-linear situations, they must be represented by combining probabilistic models of the overall behavior of the process with a standard time-keeping system. And third, an effective construction will deliver very high levels of consistency, precision, and replicability. Nonetheless, once a time-keeping system includes such necessary elements, the actual language, symbols and interval schemes adopted will be matters of convention.



Constructionism: Some Implications

Some Definitions

Change in a Physical Process: *df.* A *change* in a process *just is* a sequential difference in that process under some description.

Change in a Physical Particular or Complex: *df.* A *change* in a particular or complex *just is* a sequential difference in that particular or complex under some description.

Some Implications

Events -- Events, taken only as causal sequential differences, occur tenselessly and may not have discrete boundaries. Events, taken as bearers of spatial and change (temporal) properties, are – as time-stamped -- *products* of a descriptive temporal system.

Causal Paths – Causal paths, taken as the products of causal interactions where time stamps can be placed, may or may not be deterministic and will exhibit intrinsic property occurrences as well as, perhaps, extrinsic property gains and losses along each path with varying residual persistencies.

The Present – "The present" is ambiguous and often indeterminate in its reference. If spoken or experienced, it usually refers to a subjective event at some location in four-dimensional spacetime and can vary in extension from a near-instant to an extended observable period. If not spoken or experienced it may refer to any calibrated change at any of an infinite number of possible spacetime locations in the manifold. Philosophical presentists are usually taken to refer to present events of the first type. Constructionism holds that "the present" can permissibly refer to either some non-durational timestamp, or to an arbitrary interval, on a constructed timeline.

Implication for Time Series A

The language used by Time Series A implies that '*the* future', '*the* present' and '*the* past' designate real things, i.e., that *there are* such things as the past, the present and the future. Constructionism rejects this implication as question-begging and, in the case of 'the future', holds that it lacks truth-makers. Unless we are eternalists, 'the future', taken as a set of events, has no members.

Front Notes: Constructionism: Objections and Replies

Constructionism is closely related to the theory of relationalism which was well-described by H. Mehlberg who nevertheless argued against it in favor of the block theory of the universe and time:

"The relational theory of time amounts to the claim that temporal entities such as instants, time-intervals of some finite length, the time elapsed up to a given moment, or from a particular instant on, or from minus to plus infinity, are all of them spurious. What really exists are events or processes. Specifically temporal entities, including time itself, enjoy a merely derivative existence-status." H. Mehlberg et al., *Time, Causality, and the Quantum Theory,* D. Reidel Publishing Company, Dordrecht, Holland 1980.

Some recent philosophical work on time that advances a theory of timelessness, i.e., that time is not needed in science, nevertheless supports some of the basic tenets and conclusions of constructionism:

"We can use causation in the absence of time as a new foundation for agency. In this way, we show that agency provides no reason to suppose that time, in the folk sense, must exist. . . By drawing on work in quantum gravity, we offer a quick argument for the conclusion that our best science is compatible with the absence of time." Samuel Baron, Kristie Miller, and Jonathan Tallant. *Out of Time: A Philosophical Analysis of Timelessness*, Oxford: Oxford University Press, 2022.

Constructionism: Objections and Replies

Objection I: For an object O to undergo change it needs to gain or lose some property P. Since "O is P" and "O is not P" cannot both be true, change appears impossible unless P belongs to O *at a time* that differs from *a time* that not-P belongs to O. Constructionism precludes this solution by holding that time is not a property of O.
Reply to Objection I: "O is P" can be a true description of O as a *secondary property* of O at some time t. If we assume P is a contingent rather than an intrinsic property of O, P will be true of O at some time *t* as *an external temporal fact* about O. That is, "O is P at *t* " will be true if P is truthfully clock-mapped onto O at *t.*

Objection II: Time is an essential property of spacetime in the theories of relativity. How can time be merely a contingent description of causal sequential difference?
Reply to Objection II: In relativity 'time' is the name given to the calibration of movement and change produced by using a standard clock, i.e., a device that provides a reference standard for measuring such movement and change. Constructionism preserves this essential feature of relativity and is entirely compatible with it.

Objection III: Constructionism fails to adequately describe and support the bundle theory of properties in particulars and complexes and, therefore, neither the properties that change nor the way that time captures that change.
Reply to Objection III: Constructionism asserts only that time is not an intrinsic property of the world generally or of any particular thing and is, rather, a descriptive system for measuring causal sequential difference. As such, it requires only that there be a method for tagging the arbitrarily selected non-dimensional 'ends' of any process, the extension of which can be measured with a clock, etc.

Objection IV: There is no basis in constructionism for preserving the present as something real.
Reply to Objection IV: Constructionism holds that *occurrent intervals* (short or extended) on relativistic causal paths are real and that their temporal descriptions refer and are true. That is, they have truth-makers whereas future events do not. Existential quantifiers for prior (past) events range over the class of *causally residual* truth-makers, i.e., over the persisting causal effects of prior events.

IN TIME

SHORT ESSAYS AND VERSE IN THE PHENOMENOLOGY OF TIME

Phenomenology

Originally, the philosophical study of the structure and conditions of conscious experience from the first-person point of view independent of conventional and theoretical concepts. Notable early practitioners included Edmund Husserl, Martin Heidegger, Jean-Paul Sartre and Maurice Merleau-Ponty. More recently, phenomenology has encompassed a variety of methodologies employed in philosophy and some scientific disciplines to study subjective experience, including the 'phenomenality' or 'feel' of conscious experience. The term derives from the Greek *phainómenon*, "that which appears."

THE PHENOMENOLOGY OF TIME

Work on our experience of time has recently accelerated. This area of inquiry has attracted philosophers, neuroscientists and psychologists. Careful not to prematurely assert the *causes* of time consciousness, scientists and psychologists have looked for strong *correlations* between neural states and temporal experience. And philosophers have emphasized the structure, effects, implications, and ontological commitments of temporal experience. However, the often diffuse and interwoven modalities of conscious and unconscious temporal experience – including dream experience, synchronicity, inattention, suppression of temporal noise, and sensory deprivation – remain areas open for study.

'Here we emphasize an often under-represented aspect in the debate: time consciousness. Consciousness and the present moment both extend in time. Experience flows through a succession of moments and progresses from future predictions to present experiences, to past memories. However, . . many dominant theories of consciousness only refer to brief, static, and discrete "functional moments" of time. . . This confusion between short and discrete versus long and continuous is, we argue, one of the core issues in theories of consciousness." Laclan Kent and Marc Wittman, "Time Consciousness: The Missing Link in Theories of Consciousness." *Neuroscience of Consciousness*, 2021, 7 (2), p. 1.

"I develop a detailed differential latency model of apparent motion to show how the ordinality of experiential content is isomorphic to the ordinality of relevant brain processes. . .the theory presented has resources to account for other key features of the specious present, including the representational discreteness between successive conscious moments as well as the phenomenological continuity between them [and] the plausibility of an extensionalist philosophical theory. . ." Mathew Stuart Piper, "Neurodynamics of Time Consciousness," *Consciousness and Cognition*, 2019, 73, 102751.

"This simple overlap theory – which makes no distinction between awareness and contents – entails that co-consciousness not only connects simultaneous experiences, it also ranges a short way over time. . . The overlap theory accommodates our direct experience of change and respects the phenomenal bonding constraint: experiences occurring at different times are linked by precisely the same relationship as experiences occurring at the same time: direct co-consciousness." Barry Dainton, *Time and Space*, Montreal & Kingston: McGill-Queen's University Press, 2010, p. 114.

Front Notes: Minding Time

"Simple phenomenal content is always temporal *content. This is to say that it always contains temporal information, and this information is depicted as invariant: the state of affairs in question is holding* exactly now. . .*We now see that the principle of presentationality can be generalized to the class of all phenomenal states. . .The conscious correlate of this functional property is the phenomenal experience of an instantaneous and simultaneous givenness of certain contents, and also of their dynamical evolution within* the current moment." Thomas Metzinger, *Being No One*, The MIT Press, Cambridge, 2003, p. 128.

Temporal experience involves the coherent integration of relevant perceptions, interpretations, prioritizations and brain processes. The latter, in turn, requires the entropy of the involved (integrated) brain system to be less than the sum of the individual entropies of the involved brain processes. This is thought to occur when there are robust interactions among individual operations. *"Thus, integration measures the loss of entropy that is due to the interaction among its elements. The stronger the interactions among the elements of an isolated system, the greater their overall statistical dependence and the higher their integration."* Gerald M. Edelman and Giulio Tononi, *A Universe of Consciousness*, New York, Basic Books, 2000, pp. 121 – 122.

Minding Time

"That stretch of time over which a mental act can be extended I call its presence-time." William Stern, *Mental Presence-Time*, The New Yearbook for Phenomenology and Phenomenological Philosophy, 5, Seattle WA, Noesis Press, 2005, pp. 310 – 351.

"The theory of clocks imposes on time a certain featurelessness which runs counter to our understanding of time as the concomitant of consciousness, the condition of activity or the realization of possibility into actuality." J. R. Lucas, *A Treatise on Time and Space*, London and New York, Routledge, 1973, p. 68.

Time Tracks

Time tracks make us.
They come with pace and voice,
coming as us, into us,
some languid and frenetic
some over-running,
some seen and some not.
Some as us and world as one
and some, as us, apart.

We are compacted time, constructed time,
the synchronicities and dissonances
of our sense of our senses.
And we are the unity
of doing and breathing
and reacting and thinking
predictively, reflectively.
We are the oscillations of
brain and tissue clocks,
of clocks within clocks,
winding one way and then another.
We come as time, we make time.
As experience we are time.

Time tracks make us.
They are the narrative of us, the sensate now,
and the scaffolding of what can be.

Front Notes: Brain Work: Composing Time

"Herein, we considered the neural representation of time based on mounting evidence of the neural correlates of time perception. The passage of time in the brain is represented by two types of neural encoding as follows: (i) the modulation of firing rates in single neurons and (ii) the sequential activity in neural ensembles. Thus, the two types of internal timers distributed across multiple brain regions simultaneously engage in time perception, in response to implicit or explicit time demands." F. Sawatani et. al., "The Neural Representation of Time Distributed Across Multiple Brain Regions Differs Between Implicit and Explicit Time Demands", *Neurobiology of Learning and Memory*, 199, 2023, p. 1.

"In a reversible process, every intermediate state between the extremes is an equilibrium state, regardless of the direction of the change. In contrast, an irreversible process is one in which the intermediate states are not equilibrium states, so change occurs spontaneously in only one direction. As a result, a reversible process can change direction at any time, whereas an irreversible process cannot. For a given system, the greater the number of microstates, the higher the entropy. During a spontaneous process, the entropy of the universe increases." "Entropy and the Second Law of Thermodynamics" curated by LibreTexts.

"*We develop an account of experiential states as layered, or nested. We argue that this nested structure is also apparent in brain activity. The recognition of this structural homology — that both experiential and brain states can be characterized as systems of nested states — brings our views of subjective mental states into broad alignment with our understanding of general principles and properties of brain activity*." Denfield, Kyzar (2024).

Brain Work: Composing Time

"This proposal is not so very different from Boltzmann's idea that the sense of motion is created from several qualitatively different patterns arranged along the 'line of time'. . . I am suggesting that it is created by the brain from the juxtaposition of several sub patterns within one pattern. The arrow of time is not in the washing line, it is not in several pieces of washing, it is in each piece." Julian Barbour, *The End of Time*, New York, Oxford University Press, 1999, P. 30.

Brain Work

Our brains need to do the hard part:
converting bits and pieces of things,
angles, shadows and sounds
into something coherent we can use
without (actively) thinking.
It might even add some bits and pieces.
And that gives us a product, not a copy.

This inexorable arrow of time,
going from prior-to-now-to-next,
not next-to-now-to-prior,
appears inscrutable:
there is no clear cosmic case for it.
Classical mechanics works fine without it;
but thermodynamics does not.
It drives us toward greater entropy,
toward countless microstates.
Change runs toward disorder.
And time, its metric, runs with it.

Our brains do the hard part:
tracking what is prior-to-now-to-next,
composing experience in forward time,
correcting errors and predicting next,
managing nested information,
representing time without understanding it,
composing the washing line from the wash.

Front Notes: A Straddle, A Smear

Merleau-Ponty, following Husserl and Heidegger in undertaking a phenomenology of time, emphasized the experienced present as a dynamic posture toward past and future and subscribed to a version of temporal smearing whereby the experienced 'parts' of time overlap and co-penetrate. In this way, past events do not simply cease to exist. Taken phenomenologically, as opposed to objectively, time -- as temporal experience -- is therefore seen as 'self-comprehending' because of its convertibility with subjectivity. It is a lived manifold, not a simple line of time.

"His [Merleau-Ponty's] description of time, . . . draws particular attention to the priority of the present to the non-reflective character of time and to the directly accessible character of past and future. . . My primary experience of the past is its weighing down upon the now*, entering and qualifying it. The future is also available in experience but not as an event. It is a* style *with its own extension in my present . . . One cannot say that the various moments* are *successively nor simply that each is and then is not. Rather, they are differentiated within a single flow that both maintains and banishes them."* John F. Bannan, *The Philosophy of Merleau-Ponty*, New York, Harcourt, Brace & World, 1967, p. 128.

A Straddle, A Smear

"On his [Mellor's] account, there is no room for temporal smearing, while I have been arguing that there must be temporal smearing – on a small scale— because there must be spatial smearing (on a small scale) of the point of view of the observer." Daniel Dennet, *Consciousness Explained*, Boston, Little, Brown and Company, 1991, pp. 151-152.

A Temporal Straddle

This time
this present
seems a straddle:
something synthetic
I have conjured.
It comes (yet I may miss it)
as just then, just now,
just next;
entangled, blurred,
and evanescent,
leaning forward,
bracing backward,
holding now.
No bloodless instant of spacetime,
this is the near here –
a smear of me and elsewhere –
Yet I am in and of
the whole of it:
just then, just next, just now.

Front Notes: Remembering, I Think

"Tulving (1985) described episodic memory as the set of processes that allow us to mentally time-travel and to re-experience a past moment in time. To be able to do that, we must first take information that comes in through our sensory stores and our working memory and then create a mental representation of a moment in time; this is the process of encoding. If we want that representation to be accessible later, we must store it in some durable form; this is the process of consolidation. And, when we want to later reflect on that moment in time, we must engage retrieval processes to do so. We argue that one function of consciousness—and more importantly, what it initially developed to do—is to allow for each of these phases of episodic memory. Consciousness binds elements of an experience together, allowing for the creation of a memory trace that can include multisensory details. Over time, consciousness provides a medium in which these memory traces can be replayed—a mechanism that is key to their successful storage." Andrew E. Budson et.al., "Consciousness as a Memory System", *Cognitive and Behavioral Neurology*, Baltimore, 35 (4), December 2022, p. 267.

"These findings suggest that details freely recalled from one-time real-world experiences can retain high correspondence to the ground truth." Diamond, N. B., et. al., "The Truth Is Out There: Accuracy in Recall of Verifiable Real-World Events", *Psychological Science*, 2020, *31*(12), pp. 1544-1556.

Remembering, I Think

"Confidence, even of the highest degree, is no guarantor of accuracy. Many of the memories in which we have the utmost confidence can turn out to be, in varying degrees, inaccurate." Mark Rowlands, *Memory and the Self*, New York, Oxford University Press, 2017, p. 119.

Remembering, Perhaps

When I am sure
that I remember
I see it goes well
with other things
I am sure that I remember
until, perhaps,
being unsure,
I may yet declare I do remember --
or that I do not;
yet if I do, I deceive,
and if I do not,
I confound,
for surety of little
cannot go with
surety of much.

Still, I may stand as first I stood,
remembering this and that
in the circle that is me
perhaps untested in any world that is not,
where conjury and mimicry may rise together
as certainty.

And so it is that in remembering,
in knowing what was once before
and is not now,
I should know how I know I remember,
to be sure of it.
And the ground of that
will be, I think, far more than can be me.

Front Notes: A Simulacrum

Experience, consciousness, personal identity through change, and the ordered self are inseparable from the modalities of subjective time. Attaining subjective clarity can be difficult.

"A very simple discussion of the meaning of self-reference … unfolds into many ideas. Not surprisingly, we encounter wholes and parts, distinctions, pointers and indications, local-global, circulation, feedback, recursion, invariance, self-similarity, re-entry of forms, paradox, and strange loops. But we also find topology, knots and weaves, fractal and recursive forms, infinity, curvature, and imaginary numbers." Kauffman, L. H., "Self-reference and recursive forms.," *Journal of Social and Biological Structures,* 1987, (10), p. 53.

"If there is such a thing as you--if there is anything sitting there and reading this now--then some conditions must be necessary and sufficient for it to persist. Those conditions will involve psychology, or some sort of brute physical continuity, or something else." Eric T. Olsen, "Personal Identity", Stanford, *Stanford Encyclopedia of Philosophy*, 2002.

"What is the thread linking the diverse processes related to the self? We argue that this is what Damasio calls the 'core self'. . .Anatomically the 'core self' is associated with the orbitofrontal and ventromedial prefrontal cortex. We suggest that this concept might be analyzed in further detail. What is the 'core'? We believe that this is the processing of self-referential stimuli, and the cortical midline structures seem to be crucial for this". Georg Northoff and Felix Bermpohl, "Cortical Midline Structures and the Self," *Trends in Cognitive Sciences*, 8 (3), 2008, p. 103.

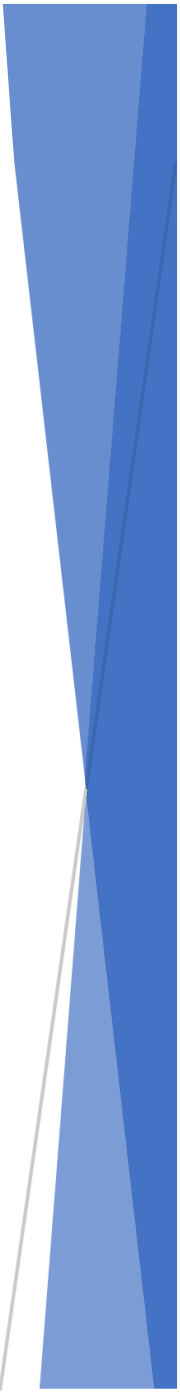
A Simulacrum

"Selves and the like are indeed obscure, a kind of affront to us in times of stern clear-headedness." Ted Honderich, *Actual Consciousness*, Oxford, Oxford University Press, 2004, p. 29.

A Mind Swirl of Time

I walk, I think, I work, I speak,
a bone blur in space
a mind swirl of my time,
a half-now, a to-be, a near-after
sliding through spacetime,
here, half-there, then nowhere –
a draft, a story,
a counterpoint to fact –
an intimation of self
a loop of within a loop,
a simulacrum of truth.

Front Notes: Finding Now, Elusively



"It is through clocks, and as clocks, that we experience time. Timelike curves are connected to ideal clocks via the clock hypothesis, and ideal clocks are an idealization of real clocks. These connections show why timelike lines are indeed timelike and why the succession of nows along a timelike curve should count as an idealized version of the passage of time. . . A universe with local passing of time is unfamiliar to most of us, puzzling to common sense; but it looks as if this is the picture of time we must learn to live with if we are to understand our universe." Steven F. Savitt, "The Transient *nows*," *Quantum Reality, Relativistic Causality, and Closing the Epistemic Circle*. Springer, 2009, p. 359, 361.

"The biological consciousness tunnel is not a tunnel only in the simple sense of being an internal model of reality in your brain. It is also a time tunnel -- or more precisely, a tunnel of presence. Here we encounter a subtler form of inwardness – namely, an inwardness in the temporal domain, subjectively experienced. The empirical story with have to deal with short-term memory and working memory, with recurrent loops in neural networks, and with the binding of single events into larger temporal gestalts (often simply called the psychological moment.) . . .The primary difficulty with the Now Problem is not the neuroscience but how to state it properly. Let me try: Consciousness is inwardness in time." Thomas Metzinger, *The Ego Tunnel*, New York, Basic Books, 2009, p. 34.

Finding Now, Elusively

"The representation of a 'Now' then becomes the simplest form of explicit time representation, as a set of recurrent loops plus a certain decay function." Thomas Metzinger, *Being No One*, Cambridge, MIT Press, 2003, p. 128.

"The very fact that one can place the event in relation to preceding and succeeding events implies both that one never experiences the now in isolation from the past and future and that one experiences the relation between now, past and future without collapsing these three modes of appearing." Michael R. Kelly, "Phenomenology and Time Consciousness", *The Internet Encyclopedia of Philosophy*, Sec. b, ISSN 2161-0002, https://iep.utm.edu/

Now, Where Now?

If I speak now
of what is not now
of what may I be said
to speak?
And if I speak now
of only now
where, in speaking so,
may I find it?
For if by now
I mean not to speak
of some other now not this,
I find I cannot find
precisely now
this now in speaking of it.

Yet, absent any now,
and being thereby not in it,
I surely should not be
some present self
I think
to query of it.

Front Notes: A Locus of Mind and Time

Our experiences are embodied. They require highly calibrated, coordinated, and dynamically predictive responses to the world: both its regularities and its disruptive outliers. And, in situations that pose great threats, we sometimes minimize perceptual chaos at the expense of what we know.

"What makes prediction fragile is then both the imperative to stem prediction error at as many levels as possible and the fact that we are restricted to using only the internal resources of the brain in doing this. The fragility can be difficult to acknowledge both because, to most of us, perception seems remarkably robust throughout life, and because, on the prediction error minimization scheme itself perceptual inference is supervised by the reliable statistical regularities offered up by the world." Jakob Hohwy, *The Predictive Mind*, Oxford, Oxford University Press, 2013, p. 227.

"At multiple time-scales and using a wide variety of means (including words, equations, graphs, other agents, pictures, and all the tools of modern consumer electronics) we thus stack the dice so that we can more easily minimize costly prediction errors in an endlessly empowering cascade of contexts from shopping and socializing, to astronomy, philosophy, and logic." Andy Clark, "Whatever Next? Predictive brains, situated agents, and the future of cognitive science." *Behavioral & Brain Sciences*, 36 (3), p. 195.

A Locus of Mind and Time

"The natural and unconscious capacity of human beings to anticipate most events of daily life makes possible wonderful effects in magic." Jordi Cami and Luis M. Martinez, *The Illusionist Brain*, Princeton, Princeton University Press, 2022, p. 113.

Mapping World, Mapping Time

My body gives location,
a place in the world,
a transactional locus,
an experiential locus,
a locus of body time
and world time.
A back and forth with the world.

I map it well, this world,
almost isomorphically,
getting the proportions and turns
and light and sequences
exquisitely right; most of the time.
For I would otherwise not survive.

I map it well, this world:
actively, predictively, reliably,
keeping time, concurrence,
sequence, and tracking
on track.
Most of the time, without thinking
about the thinking that is done.
Until I do not or cannot -
when the rhythms and certainties
and synchronicities
at the center of things -
come apart.

I map it well, this world.
Most of the time.

Front Notes: Music in Time, Music as Time

Music is usually experientially unified, coherent, expressive and accessible, even though it may be compositionally complex. Depending on its properties and our responses to them, it may alter and even overtake our sense of lived time. A central aspect of most music is its synthetic or composite temporal nature: it is experienced co-streamally as more than its sounded notes and individual sources.

"The overlap theory accommodates our direct experience of change and respects the phenomenal bonding constraint: experiences occurring at different times (such as [notes] C and D) are linked by precisely the same relationship as experiences occurring at the same time: direct co-consciousness. . . . [and] why does a persisting tone seem to continue on in a particular direction? There seems to be only one solution: the contents that are symmetrically joined by co-consciousness must by themselves possess an inherent directional dynamism. The C-tone is not a static auditory quality, but a flowing quality. . . This immanent flow is an essential ingredient of any auditory content, just as essential as timbre, pitch or volume." Barry Dainton, *Time and Space*, Montreal and Kingston, McGill-Queen's University Press, 2010, pp. 114 – 115.

Music in Time, Music as Time

"Music creates temporal form while unfolding in time. . . Our experience of music is ambivalent: music is particular yet universal, transitory in experience yet lasting in reflection. . . Time is experienced with intensity, yet it recedes ephemerally from our consciousness." Goetz Richter, *Thinking About Music: Music, Time and Temporality"*, University of Sydney, 2006, p. 1.

Becoming Music

It isn't voluntary,
this mind-body resonance
in music
moving deeply within,
this phenomenality
extending beyond,
suspending lived time
annulling time
becoming time
(paradoxically).
When, in genius,
it is high magic.
There is genius felt
as few thoughts can ever feel
and time felt
as otherwise it is never.
Until, at last, in irony,
such time
and resonance
as held in music
must cease,
returning to itself,
less music as music
cease as well.

Front Notes: Consciousness as Time For-Itself

The work of early phenomenologists attempted to set aside existing concepts and theories about conscious experience so that experienced phenomena could be described as '*presented*' to situated subjects. The experience of lived time – embodied and existentially engaged -- was central to that project.

"Philosophy of time should aim at an integrated picture of the experiencing subject with its felt time in an experienced universe with its spatiotemporal structure." Steven F. Savitt, "The Transient *nows*." *Quantum Reality, Relativistic Causality, and Closing the Epistemic Circle*. Springer, 2009, p. 351.

"Time is too large, it can't be filled up. Everything you plunge into it is stretched and disintegrates." Jean-Paul Sartre. *Nausea*, New York, New Directions Publishing Corp., (1938) 1964, p. 21.

"Our destiny is not frightful by being unreal; it is frightful because it is irreversible and iron-clad. Time is the substance I am made of. Time is a river which sweeps me along, but I am the river; it is a tiger which destroys me, but I am the tiger; it is a fire which consumes me, but I am the fire. The world, unfortunately, is real; I, unfortunately, am Borges." Jorge Luis Borges, "A New Refutation of Time", *Labyrinths: A Selection of Stories and Other Writings*, New York, New Directions Publishing Corp., 1962, pp. 217 ff.

Consciousness as Time-for-Itself

"The object is transcendent to the consciousnesses which grasp it, and it is in the object that the unity of the consciousnesses is found. It will be said that a principle of unity within duration is nonetheless needed if the continual flux of consciousness is to be capable of positing transcendental objects outside the flux. Consciousness must be perpetual syntheses of past consciousness and present consciousness. This is correct." Jean-Paul Sartre, *The Transcendence of the Ego*, New York, The Noonday Press, 1957, pp. 38 – 39.

Being and Time

As transparency, as *of something*,
consciousness presents as for-itself.
Apart from, yet anchored in its objects,
its possibilities awaiting grounding and unity,
it coheres as the synthesis of experience,
of time, of lived presentment,
holding to what is taken as so,
holding to what is expected as so.
Each grounding equally a fulfillment
and a threat to possibility.
An existential opening; or a closing.

Consciousness is our domain,
its dimensions variable and interwoven,
extended by drift, contracted by focus,
suspended in transcendent attention.
As consciousness we are time-for-itself,
narrative and self,
here and not.
And always exquisitely inscrutable.

Front Notes: Presence in the Present

Time is sometimes experienced almost non-durationally, in deep relaxation, concentration, meditation and even inattention. This near paradox of 'non-temporal experience' in the larger frame of commonly experienced time presents as a 'space' between events, or suspension of flow, and is phenomenologically different in its generalized and sometimes singularly intentional posture. This poem by Simon Ortiz suggests a simple 'temporal space' of attentional clarity.

The Serenity in Stones

"I am holding this turquoise
in my hands.
My hands hold the sky
wrought in this little stone.
There is a cloud
at the furthest boundary.
The world is somewhere underneath.

I turn the stone, and there is more sky.
This is the serenity possible in stones,
the place of a feeling to which one belongs.
I am happy as I hold the sky
in my hands, in my eyes, and in myself."

Simon J. Ortiz, 1975.

Presence in the Present

Conscious experience is, essentially, the experience of present subjective content. Strikingly, there can be experiences where that content becomes singularly involving and affectively dominant; where the experiencer achieves an expansive sense of self-presence as subjectivity becomes more salient, looped and amplified. The phenomenon of looped subjectivity, which is often only implicit in conscious experience, can itself become an explicit object of conscious experience. In other instances its presentation may oscillate between the foreground and the background and in still others it may recede altogether as a positional feature of the experience. In each of these instances, whether an indexical subject is constituitive of the experience or not, the sense of present time can be greatly extended and amplified.

Time as Time Not (Nearly)

Time without time happens.
Or so it seems at times,
for me.
Edges fall away
blur, then vanish,
as the center of mind resolves,
becoming all of mind:
clarified, whole, transcendent.
The larger world now
nearly not, with no hold.
Heart and breath and blood
shorten, become silent.
A near null time this,
that oddly, as singular,
is a seeming moment
without interval or succession,
without expectation,
and wholly now in its difference.

And wholly unsustainable.

Front Notes: With the Flow, In the Moment

Our experience of time often consists in an experience of *what* we perceive, with its temporal characteristics, as well as an experience of *how* we perceive those characteristics. This may occur synthetically as percepts and the concepts they implicate are colored by disposition and perspective.

"What makes the experience of temporal properties like change special and philosophically interesting? At least one fact that makes it special is that our experience not only represents temporal properties, but also has temporal properties. For example, not only do you experience change but your experience itself is also changing over time. Your experience is, as William James famously said, a temporally changing 'stream of consciousness'." Sebastian Watzl, "Silencing the Experience of Change," *Philosophical Studies*, 2013, Springer, 165 (3), p. 1010.

"Since [for Husserl] the now and past are not a part of time but the modes by which things appear to me as temporal, each now that becomes past can accommodate many events simultaneously. . . The very fact that one can place the event in relation to preceding and succeeding events implies both that one never experiences the now in isolation from the past and future . . our preliminary reflections on time depend upon a series of successive events but a succession of experiences or perceptions is not yet an experience or perception of succession." Michael R. Kelly, "Phenomenology and Time-Consciousness," *Internet Encyclopedia of Philosophy*, https://iep.utm.edu/phe-time.

With the Flow, In the Moment

[Csíkszentmihályi described flow as] *"being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved . . ."* Interview with Mihaly Csíkszentmihályi: John Geirland, "Go with the Flow," *Wired*, 1996, September Issue, 4.09. Here is a briefly immersive moment:

A Red Feather

I held a red feather,
seeing sunlight
in the reddened air
beneath it.
A stillness in the feather
that once was flight,
and life,
held a stillness
at the end
of the arc
of the flight
in me.

I held a red feather,
seeing sunlight
in the reddened air
beneath it.
In simple grief
for loss of beauty
and loss of flight
I held a moment,
inside another,
like one
not found before.

Front Notes: World, Experience and Continuities

Intensively debated is the question of whether our experience of external temporal succession – where one physical event, state or property is followed by another – requires that our experience *itself* have the same temporal structure, i.e., that it have the same presentation, order and duration.

"I outline a positive account of temporal experience, according to which an appearance of succession requires a succession of appearances. . . in the case of temporal experience, it so happens that appearances of succession are, in fact, successive." Oliver Rashbrook, "An Appearance of Succession Requires a Succession of Appearances," *Philosophy and Phenomenological Research*, Vol. 87 No. 3, 2013, p. 609.

"Against the Process Intuition, I'll be arguing for an "Atomic View" on which there is an important sense in which temporal experiences are not temporally structured processes. Against the Mirroring Intuition, I'll be arguing that temporal experiences are not constrained to have a temporal structure that in any way mirrors the temporal structure of the events they present. Against the Representation by Resemblance Intuition, I'll be arguing that temporal experiences are underwritten by neural states that do not represent temporal features through resemblance, and that this implies that experience itself does not represent time by resemblance." Geoffrey Lee, "Temporal Experience and the Temporal Structure of Experience," *Philosopher's Imprint*, 2014, 14. (Article 3).

World, Experience and Continuities

In Search of a Good Theory

Imagine everything comes in bits,
that everything at its lowest
is irreducibly small,
that what we sense (the bits)
is not what we perceive (the process),
that everything comes in a
"this-then a gap-this-then a gap" format,
that the world comes as
a film strip of 'stills',
that the movie is in us,
that all temporal experience is a product,
a construction from tiny sensory bits
and that we are the makers,
the temporal compositors,
that our experience of time itself
is synthetic, made of micro-experiences
arrayed and presented
as seamless experiential wholes,
realized by clusters of neural states
multiplexing in the brain.
It could be this way say some; especially the magicians.

We need a good theory.
One that accounts for what we already know:
for the plasticity and speed and dynamism
and ease and coherence of our event space
and for our supple perceptual capacities.
For how we are built, for what we can conceive,
imagine and handle, for the normal,
the cascading, the swirls,
the jarring, the new, the stillness,
the order, the continuities,
and our deeply rich phenomenal moments.
A theory that represents the world
and what we are in it.

Front Notes: The Present as Future

The temporality of personal consciousness is extended forward and backward, from the lived present, into a predicted future, from an adjusted model of the lived past into the present and, again, into the future. It is reciprocal and dynamic. In this way the lived present is as much about what is expected as about what has happened and is happening now.

"This means that perceptual content is the predictions of the currently best hypothesis about the world. Perceptual inference is always trying to use its prior knowledge to predict and suppress the sensory input the system is receiving. . . The hypothesis with the least error is the hypothesis that determines perceptual content and this hypothesis is internal, subject to statistical decisions and expectations of noise and different from the hidden causes making up sensory input. [Perception] is indirect in the sense that what you experience now is given in your top-down prediction of your ongoing sensory input, rather than the bottom-up signal from the states of affairs themselves. . .The predictions of the internal models that determine perception are supervised by the world itself. This follows from the re-conception of the bottom-up sensory signal as prediction error – as feedback to the model of the world. The prediction error is essentially a feedback signal that informs the brain that it has not yet gotten things right." Jakob Hohwy, The Predictive Mind, Oxford: Oxford University Press, 2013, pp. 48-49.

The Present as Future

"This model views the sequence of moments contained in the specious present not as a series of mere contents but instead as a series of contradictory ones, the combination of which in our retentional awareness giving us the impression that at present a brief slice of change and temporal passage is taking place." Corry Shores*, "Dialetheism in the Structure of Phenomenal Time*," *Logical Studies of Paraconsistent Reasoning in Science and Mathematics*, Trends in Logic, Vol. 45. Cham, Switzerland, Springer Nature, 2016, p.157.

Now and Next

This extended present does not come
with a sharp front edge.
An edge like that would kill
any now, and the next one.
Each common now comes with
an implied future.
Not a guaranteed future,
just a silently posited
and contingently personal future
in the experience of living and leaning forward.
Few moments come with silent time tags
or little mental markers
saying "this is now" and "this is next."
We get only our experiences,
the multiplexing of events,
the momentary branching
and inconsistencies of change
in our narratives.
The emerging timelines of ourselves.

And, trenchantly,
we learn what 'was' next
only once it is not.
And, instead, now.

Front Notes: Extensionalism vs. Atomism: The Structure of Temporal Experience

The hypothesis that conscious experience is temporally extended and that the order and duration of conscious contents is explained by the order and duration of experiential processes is extensionalism. This hypothesis is challenged by atomists who deny that the timing of experiential processes explains the temporal content represented in experiences. This narrow debate is important for understanding a key feature of temporal experience, but it is largely irrelevant to understanding the full phenomenal character of temporal experience itself, which includes elements such as stability, concurrence, latency, multivariance, duration, simultaneity and noise.

"An in-depth understanding of the relevant neurodynamics shows that the ordinal phenomenology of apparent motion resembles and hence is arguably explained by the ordinal progression of oscillatory mechanisms. I endeavor to show that extensionalism is a viable and plausible theory of immanent temporal consciousness -- i.e., the specious present -- despite temporal illusions and the fact that representational content determination is typically non-resemblant vis à-vis its neural vehicles. . . I [distinguish] brain time (i.e., the timing of neural processes) and experienced time (i.e., time as consciously experienced). Extensionalists hold there is an explanatory resemblance between the two (brain time -> experienced time); atomists deny that any such resemblance, even if it existed, would be explanatory." Mathew Stuart Piper, "Neurodynamics of Time Consciousness," *Consciousness and Cognition*, Vol. 73, August 2019, 102751.

Extensionalism vs. Atomism: The Structure of Temporal Experience

"Extensionalist theories of the specious present suggest that every perceptual experience is extended in time for a short while, such that they are co-extensive in time with the time experienced in them. Thus, there can be no experience of time, unless the experience itself is extended in time." Jan Almang, 2021, "A Problem for Extensionalist Theories of Time-Consciousness," Synthese (2021) 199: 14865–14880.

So, it may be that the time *experienced*,
and the time *for that experience*,
closely *resemble* each other and are co-extensive.
And if time *as experienced* does not closely resemble
the time *for an experience*, time *as experienced*
may be a product, not a direct read-off from the world.

Let's consider experience itself and the changes within it that we frame as "now," "before," and "after." Consider this reverie:

. . . eyes closed, a guitar strumming to my right – eyes closed, the soft texture of the armrest of my chair – eyes open, low chatter and glasses clinking at the table next to me, a waiter crossing to my left, a fleeting image of a dark bird streaking by the window just ahead, the pressure of the chair against my back, the strong flavor of mustard and pork on the fork, a recurring tune 'playing' in my mental background, a clock on the wall reading half-past, a room full of countless details I will be unable to remember – eyes open, man rising from the far table as I lower my fork. . .

This stream of consciousness suggests an extraordinary thing about temporal experience: the simultaneity and dynamic concurrence of so much change and difference in a single perceptual setting of remarkable detail, stability, fidelity and continuity, all processed attentively and with the possibility of selective focus on events changing at different externally and internally calibrated rates.

On this basis, I suggest, extentionalism has stronger credentials than atomism.

Front Notes: The Self In and Through Time

"There is thought to be a rich connection between the self and the phenomenology of episodic memory. .The self is a multidimensional, rather than a unidimensional, construct. . we have demonstrated how the phenomenology of episodic memory can be modulated by focusing on different facets of the self. The self involves embodied, extended, embedded, and ecological dimensions, all of which can modify the way in which we experience the recall of events in our personal pasts." Roy Dings and Christopher Jules McCarrol, "The Complex Phenomenology of Episodic Memory," *Journal of Consciousness Studies*, 29, No. 11 – 12, 2022, pp. 50-51.

A central issue in the philosophy of time concerns whether the mental states and acts of persons constitute selves with causal powers that are not fully explained by physical laws. That is, can we be genuine causal agents and is agency confined to the present? Opposition to the claim that mental events can cause physical events often relies on the Causal Closure Principle which holds that no physical effect can be caused by a non-physical state, event or act. This principle is now undergoing a reassessment. *"Philosophers of mind are beginning to challenge the causal closure principle as a result of closer investigation into what physical science itself has to say about the causal structure of the physical domain. Hendry (2006) challenges the causal closure principle in the domain of chemistry. The principle has also been challenged in the domain of physics itself. To accommodate the indeterministic aspect of quantum mechanics, probabilistic versions of the causal closure principle have been advanced. But this does not engage with the deeper issue—namely, that quantum systems are arguably holistic systems, and that the holistic nature of these quantum systems conflicts with the causal closure principle."* Durham Research Online 2014.

The Self In and Through Time

The nature of the self, and whether selves can even be said to exist, remain difficult and contentious philosophical and psychological questions. Here, I assume that selves *do* exist as agents and as experiential constructs. Namely, as products of mental processes instantiated in, but not reducible to, physical neural states. This position is underwritten by a type of philosophical *monism* holding that some mental states are ontologically conjoint with, yet causally distinct from, the neural states they configure which, in being so configured, acquire new non-lawlike causal properties. Configured physical states acquire artifactual causal properties attributable to that configuration. Selves, as agents, are in the causal mix.

Here is a reflection on self through experiential time:

Just Beyond Reach

When I think about the thinking
that I do
I find myself in little of it,
at least not the self that knows what it is thinking.
Yet, still, there is some sort of me
in all of it
versions of something arguably me
laid down somehow
at some time
that drive and shape the now of me.

Thoughts from the unseen
many of me,
and the working aware
now of me,
resolve themselves,
reciprocally
I think,
to make and keep
a settled narrative of me;
that is, of most of me.
And then I act.

Front Notes: Memories: The Making of Self

Infants exhibit tracking memories and awareness of process, perhaps the precursor of fully developed temporal experience. In developed memory systems autonoesis appears to play a critical role in the development and experience of self (and time).

"*Infantile amnesia, the inability of adults to recollect early episodic memories, is associated with the rapid forgetting that occurs in childhood. It has been suggested that infantile amnesia is due to the underdevelopment of the infant brain, which would preclude memory consolidation, or to deficits in memory retrieval."* Christina M. Alberini and Alesio Travaglia, "Infantile Amnesia: A Critical Period of Learning to Learn and Remember", *Journal of Neuroscience*, 2017, 37 (24) p. 5783.

One possibility here is that autonoesis itself directly grounds a sense of subjective certainty that an apparently remembered event really happened, enablin the subject to act on remembered information rather than floundering in uncertainty. Another possibility is that autonoesis serves as one of several criteria . . . that enable the subject to tell whether he is remembering or imagining." Kourken Michaelian, "Memory," *The Encyclopedia of Philosophy*, 2017.

How can we know that we remember correctly? When we believe we remember external events we can consul an external record. When we believe we remember subjective events we may consult others as well as the order and reasonableness of our memories.

"Our concept of memory would be incoherent unless our concept of the past were such that it was always logically possible for us to remember correctly our own correct rememberings." J.R. Lucas, *A Treatise on Time and Space*, London and New York: Routledge, 1973, p. 266.

Memories: The Making of Self

Achievements in the study of memory have been enormous. Researchers and theorists have developed many classifications of memories to target and test their conceptual and empirical work. These have included: declarative, non-declarative, working, prospective, semantic, episodic, iconic and auto-biographical memory systems. These systems inform our perception of time.

Resources of Memory

When I speak or search for facts
I often learn what I think or say
after saying it, and maybe even after
some silent editor appears from elsewhere,
interrupting as I try to speak.
I know *I* am speaking but I also know
there is a second, implied speaker:
a concurrent voice working just 'beneath'.
Yet, this speaking and thinking and remembering
may come quietly, as thinking I cannot recount,
running in imperceptibly from somewhere,
unless I am deliberate.
And this way of remembering is unlike
the one that shows I am, and have been here,
and that I am the person who was
at some place and time before,
just because that memory has me in it.
And that remembering is even more unlike
my memory of just now,
and the next just now and the next.
These are the timelines of me,
the concurrent paths of me,
the tracks I have to call my own.
They interweave, often seamlessly,
as the unity of my experience.
They are existential, personal, embodied,
at-work, sustaining a contingent grasp
on world and time.

Front Notes: Temporal Disorders: Breaking the Self

"Time experience has repeatedly been proposed as disturbed or altered in mental disorders, and particularly in schizophrenia. Meta-analysis of time perception and temporal processing has suggested that patients with schizophrenia may be liable to a higher variability in the function of an internal clock mechanism. Structural psychopathology has implicated a disturbance in time experience as the phenomenon potentially underlying several core features of the disorder. The concept most frequently brought forward proposes that this is caused by a disturbance in the basic sense of self due to a fragmented or dis-articulated time experience. According to this concept the temporal continuity underlying conscious awareness no longer proceeds smoothly, but disintegrates. The automatic implicit incorporation of new and salient information into an ongoing stream of consciousness fails and the integration of perceptual information over time into a coherent sequence of meaningful events is no longer possible. Symptoms of schizophrenic psychosis have been described as a retroactive compensatory mechanism that reduces uncertainty, surprise, and subsequently fear, that is caused by the unpredictable perceptual input; e.g. delusive perceptions as alternative explanations for unpredicted events, delusional thought and systematized delusions as an alternative explanatory model, or thought insertions and hallucinations as thoughts externalized from basic self-continuity." D.H.V. Vogel, et. al., "Disturbed Time Experience During and After Psychosis," *Schizophrenia Research: Cognition*, Amsterdam: *Elsevier*, September 2019 (17), 100136.

Temporal Disorders: Breaking the Self

The unity and functional capacities of consciousness, the possibility of coherent subjective experience, and the possibility of phenomenality itself (i.e., the sense of "what it is like to be this person now") require the successful processing and representation of internal and external events and their cross-relations. They require the coherent experience of contextualized change and, therefore, of its calibration, of subjective time.

These achievements secure models of the external world and of the self as stable continuities. Autonoesis, which is widely believed to be required for this to happen, requires an indexical (positional) frame of reference and a logically consistent representation of the world and the personal present, past and possible future.

Indexicality Postulate: functional conscious experience requires coherent processing and modeling of external and internal sequences including correct inferences to causes and effects in sequential order, date-stamping events and marking those sequences with accurate and consistent temporal tags.

Possible Constructionist Implications: as constructions, external and internal time schemas have logical properties, including varieties of *transitivity* and *equivalence*. In particular (">" *df.* "greater than"):

- If A > B and B > C, then A > C [*transitivity*]
- If A = B and B = C, then A = C [*equivalence*]
- If A before B and B before C, then A before C [*transitivity*]
- If an event is date-stamped 'yesterday', it cannot be also date-stamped 'today' or 'tomorrow'. [*non-contradiction*]
- Experienced temporal values can be taken as subjectively functional (real) when they are consistent, coherent, ordered sequentially, grounded and congruent with other known temporal facts.

Disturbed temporal experience may involve violations of these and other logical relations of time, understood as a construct. I conjecture that violations of these relations could undermine interpretable sensory experience, coherent perception, conceptual processing and a stable sense of self.

Front Notes: Reconciling External and Internal Time

As embodied experiencers – perceivers, agents, observers, consumers, participants, designers, conceptualists – we inhabit (and are fundamentally) the multi-modal world of space and external and internal time. As experiencers we sense, perceive, and conceptualize change, both external and embodied conscious change. And we learn to function in each of these experiential setups. Clear differences in the boundaries and operational characteristics of these setups can lead easily to the conclusion that time differs profoundly between them. This conclusion seemed particularly apparent with the advent of the theories of relativity which appeared to undermine intuitive notions of temporal order. The position taken here is that such a conclusion would rest on a misunderstanding of external time.

"The concept of time is an abstraction or generalization from change, especially repetitive, regular change. Transience or change is the essence of time." Robert M. Anderson, Jr. and Alexandra T. Davis, "Reconciling Temporal Experience with Physical Time," Online, 2022, p. 5.

And, regarding our consistent experience of the asymmetry of external time: *"Now if perspectivalism cannot meet the challenge to explain why, when B is perceived as following A, A is never perceived by the same observer as following B, it seems that our experience of time order, insofar as it has a causal explanation, requires causation to be objectively asymmetric.*" Robert Le Poidevin, "The Experience and Perception of Time," *The Encyclopedia of Philosophy*, 2019.

Reconciling External and Internal Time

It may appear that subjective time (time as experienced) and external time (world time as standardly measured) differ profoundly and may be inconsistent. I maintain that they *are* different, but not profoundly so, and that they are not intrinsically inconsistent.

External time is the calibration of real processes and events in the external world -- and is the product of applying conventional event measurement standards to them. Subjective time, although embodied in the external world and intimately grounded in it, is nonetheless different, being intrinsically experiential and the product of dynamic, nested, re-entrant and self-referential signal and information processing systems, multi-modal conscious and unconscious states, and event management processes. It is often attentionally selective and geared to processing information with varying priorities and at different internally calibrated rates. When internal time is unconscious it is likely a property of underlying neural control and regulative processes. When it is conscious, it is usually indexical, occurring from a point of view as well as bimodal, representing external time as well as subjective rates and duration.

Subjective experiences, especially their temporal aspects, are generally similar to, and convergent with, the subjective conscious experiences of others. That is a pre-condition for communication. Yet, they are phenomenally specific for each subject. These personal aspects of subjective time seldom conflict with our experience of external time and, when they do, are commonly given less weight than external time. That said, occurrent internal time experiences – unlike our perceptions of external time – have phenomenal properties, i.e., they have a 'feel' to them.

We do not yet understand how internal time consciousness and our perception of external time are causally and experientially related. The opportunities for accelerated research and theory development here are large and promising as we move away from the view that external time is independently real and that subjective time is an imperfect perception of external time. Instead, internal time experience must be seen as essential for function, perception, comprehension, imagination and predictive world engagement.

TIMELINES

Glossary of Key Terms

GLOSSARY OF KEY TERMS

Arrow of Time -- The directional nature of world time, from a fixed past through the present toward an open future. This apparently independent asymmetry of time leads to our experience of time passing. It is widely believed to be a consequence, or a corollary, of physical phenomena represented by the second law of thermodynamics, namely, the statistical principle that physical states and events follow a path toward increasing disorder, or entropy. Some theorists deny that time is fundamentally directional.

Autonoesis – the conscious recollection of a personal experience, wherein the remembering subject is situated in that memory, as well as, generally, the capacity to place oneself in a remembered past, an imagined future or an entirely imaginary event. This ability is often characterized as "mental time travel."

Biological Clock – Endogenous (internal) timing mechanisms in the bodies of living organisms, responsible for regulating various cyclical processes and responses.

Block Universe Theory of Time -- The theory of time which holds that the universe is defined by an unchanging four-dimensional "block" of spacetime rather than by three-dimensional space that is continuously configured the passage of time. In the block theory of time all points in spacetime are equally real or can be said to have the same metaphysical standing. It is sometimes referred to as eternalism.

Cause, Causation – *Weak Cause*: a state of affairs sufficient to produce another state of affairs. *Weak Causation*: the sufficient process or event of producing a state of affairs. *Strong Cause*: a state of affairs that is both necessary and sufficient to produce another state of affairs. *Strong Causation*: the necessary and sufficient process or event of producing a state of affairs.

Chronostasis – A temporal illusion in which the initial perceptual experience of a new event or task appears to be extended or temporally suspended, as when the second hand of an analog clock appears briefly 'frozen' in place.

Circadian Clock – A biochemical mechanism found in animals, plants, fungi and bacteria, which is coordinated with the day-night cycle, and which oscillates with a period of approximately 24 hours. It is the most important type of biological clock, and is used to regulate the body's circadian rhythms.

Consciousness – Perhaps the most difficult topic in the canon of philosophy, neuroscience, brain research and information theory, consciousness is generally taken to be an experiential state of some sentient organisms, especially persons, which is multiplexed, graded, focused, unified, dynamic, rich and generally other-directed rather than directed onto itself. It manifests in different modalities including proto-consciousness, operant consciousness, acute consciousness, and diffused consciousness and can be generally sorted into phenomenal consciousness (*what it is like* to be in that conscious state) and access consciousness (employing the resources of active and latent memory).

Constructionism – The philosophical position that external (physical) time is derivatively dependent on the existence and changes in physical processes and objects, that its expression is merely conventional and that it is a calibration of the sequential differences (changes) of those processes and objects.

Continuous, Continuity – In mathematics, a function is continuous if a very small difference in a value in the domain produces a very small difference in the value (solution) of the function. Such functions have an infinite number of solutions, none of which is discontinuous. In physics and time, continuity occurs when the mathematical function that describes an object, property or process is continuous.

Coordinate Time – The time value of an object (event) in a four-dimensional space-time coordinate system for objects moving relatively to each other. In the Special and General Theories of Relatively there is no absolute standard of time (as there was in classical/Newtonian mechanics) and time must be calibrated relativistically. Time is always time from the point of view of an implied observer.

Cyclic Time – Broadly, the position that large-scale time is fundamentally cyclical and may include repeating ages in a context of universal hypertime. The pre-Socratic Greek philosopher Empedocles

held to a theory of eternal return. Some Hindu, Buddhist and indigenous tribal cultures have held similar views.

Determinism – Determinism, in its narrow and traditional form, is the philosophical position that each event B (understood as an occurrence) is strictly determined – in the sense of necessitated – by some preceding event A or by a chain of preceding events. This view is often underpinned by an appeal to physical laws which are assumed to operate invariantly and with necessity. In this way determinism has often been inferred from physical necessity. Notably, any form of determinism that is disorderly would not support the predictive requirements of science.

Duration – Duration is some temporal measure of the persistence of an entity, object, property or event. In the work of Henri Bergson duration designates a subjective experience of time that is apprehended through intuition or imagination.

Endurantism – The philosophical theory that objects persist by enduring; they are wholly present whenever they exist. They differ from perdurantists by holding that physical objects have spatial parts only and do not have temporal parts.

Entity – On one philosophical rendering, an entity is something that is real, that exists. However, this term is also used very widely in philosophy to neutrally designate a large range of objects of thought and may include merely possible, probable, fictional and theoretical things with stipulated properties.

Entropy – A quantity representing the unavailability a system's thermal energy for conversion into mechanical work, often described as the degree of disorder or randomness in the system. According to the second law of thermodynamics the entropy of a system increases with time and can never be negative. Thus, every system, and even the universe as a closed system, proceeds toward increasing disorder.

Eternalism – The view that all temporal values have equal metaphysical standing, i.e., that, in some sense, all prior, present and future events are equally 'real'. This view can seem to be a direct consequence of adopting a four-dimensional coordinate system where earlier, current and later events (point values in that

coordinate system) can be 'located' inside that system, i.e., inside any given four-dimensional light cone. It can be argued that such 'locations' have been wrongly reified as existent, or real, events on the basis that they can be found in the coordinate system.

Event – In relativistic spacetime, a four-dimensional coordinate value in the manifold. In normal parlance, an occurrence at a time.

Existential Quantification – In predicate logic an existential quantifier is a logical constant (∃) usually interpreted as "there exists." "there exists at least one," or "for some" as in "there exists an x" ($\exists x$).

Existentialism – A philosophical movement and discipline concerned with the subjective condition, with emphasis on the limits of self-representation, anxiety, finitude, freedom and consciousness.

External / Internal – A common but problematic philosophical distinction made between objects and facts that exist independently of human experience (external) and those that do not (internal). Although this distinction raises major issues about what we can/do know about ourselves and our world, it does capture the fundamental subjectivity of experience as well as our general acceptance of some form of realism (unlike idealism and phenomenalism) about the world. So, its use continues.

Future, Future Event – A period or event of or at a time which is expected to follow the present time. In eternalist theories such periods and events exist coextensively with present and past events in spacetime.

Growing Block Universe Theory of Time – The theory that prior events are real and accumulate in 'the past', that present events are real and exist now, and that no 'future' event in an unfolding universe – as future -- exists. Existence, on this view, can be properly attributed to, and only to, events that are or have been present.

Homeostasis, homeostatic – a property of complex systems, especially organic life forms, where interdependent processes and sub-systems tend toward an overall state of internal stability and external equilibrium.

Indeterminism – The philosophical position that some, and perhaps most, causes do not necessitate their effects and that instances of causal necessity, when they occur, are conditional on their circumstances -- which might have been otherwise. A strong form of indeterminism holds that many physical regularities are only probabilistic and not lawlike, with some existing at the micro-level while others exist at the level of populations and aggregates, yielding dispositions and tendencies rather than certainties.

Instantiate, Instantiation – to represent an abstraction or abstract object with a real occurrence, i.e., with a concrete instance. Or the event or state of that occurrence.

Interval – The period of time defined by and between two different events. A fundamental issue arises when we attempt to define the boundary conditions for an interval; specifically, do the boundaries themselves have duration and, if not, how can they be said to set any interval limits?

Isomorphic, Isomorphism – having the same form; the concept or property of being formally similar to something else.

Kappa Effect – A divergence between experiential time and clock time where perceived time is longer or shorter than elapsed clock time, perhaps due to the separation of consecutive stimuli.

Light, Speed of – Held to be a universal constant in a vacuum and stipulated in the theories of relativity as that speed that cannot be exceeded by any particle, wave or body in space. The speed of light has been approximated as 299,792,458 meters per second.

Memory, Episodic – The ability to retain and retrieve prior specific experiences, over recent as well as long periods of time, as well as the contents of that memory system. A *what-where-when* framework is often employed in episodic memory research. Generally, persistent long-term memories exhibit properties of salience, selectiveness, interpretation and can be remarkably veridical. Importantly, episodic memory often comes with a distinctive phenomenology where remembered events come with virtual, salient and sometimes fragmented representations of a prior experience.

Memory, Semantic – The ability to retain and retrieve knowledge including words, word meanings, concepts, ideas, facts and language. Like episodic memory, semantic memory can be differentiated as either explicit (consciously recalled and declarative) or implicit.

Memory, Working – A short-term cognitive capacity (thought to be a key executive function of the brain) – and its content -- that keeps track of key information and multiple processes and events at the same time. This capacity is attentionally focused and operates very briefly. The multicomponent model of working memory proposes three elements: a central executive, a phonological loop and a visuospatial sketchpad.

Modified Presentism – A philosophical theory of time which accepts relativistic four-dimensionalism but denies eternalism and the block theory of the universe. Instead, it proposes a dual-ontology of past and present events wherein: prior events – as prior – *were real* and their residuals *as present* residuals (diminishing) *are* real, and present events *as present* are *extended phased* events (without discrete endpoints) and, finally, that future events *as future* are not real (existent) because they have no truth-makers – though the scope of probabilities and possibilities for future events is limited by the extended present and past residuals. Constructionism is a modification of the growing block theory, but it demotes the ontological standing of prior events treating only their residuals as true relata. That is, if prior events have no residuals, they cannot be relata of present events.

Monism – The philosophical position either that there is only one existing thing or there is only one fundamental kind of thing of which all other things are composed. More narrowly, in the philosophy of mind, varieties of monism generally identify a form of being that explains existence and interaction or interdependence of physical and mental states.

Ontology / Ontological – The philosophical enquiry into the nature of what can and does exist with special attention to objects and particulars, concrete composites and wholes, persons, mental objects, percepts, events, processes, causes, actions, concrete and abstract entities and groups, classes, membership, substances, instances, properties, systems, numbers, universals, concepts, properties, fictional things and organisms. A position has ontological

implications if it implies the actual or possible existence of something.

Perdurantism – The theory that any object that continues to exist through time as a continuous entity does so as the sum of its temporal parts, or the sum of its instances. A thing perdures if (and only if) it continues to exist by having different temporal parts where no temporal part of it is entirely present at more than one time.

Phenomenology – The philosophical discipline of finding and describing the structure and most salient features conscious experience, especially those that involve intentionality (consciousness *of* something), finitude (inherent limitations of experience), world, facticity (absence of any reason for something) and embodiment without reliance on prevailing norms, theories and concepts.

Phenomenal, Phenomenality – A conscious state has phenomenal content if there is something *it is like to be* in that state. Advocates of phenomenal properties – sometimes called *qualia* – often insist that no purely physical or functional account of phenomenal experience or mental states can capture the "*what it is like*" character of such experience. "By 'conscious states' I mean phenomenally conscious states or processes, and by 'phenomenality' I mean the property in virtue of which some states or processes are phenomenally conscious. . . The ambiguity is between what I call *phenomenality* and what I call *conscious states*, where the former denotes an abstract property and the latter denotes a phenomenon or class of its instances." Mikio Agagi, "Phenomenality, Conscious States, and Conscious Inessentialism," *Phenomenology and the Cognitive Sciences*, 19, 2019, 809 – 819.

Physical Time – Time as defined externally, conventionally by astronomical phenomena, environmental and physical clocks. In physics, the principle frames of reference for defining physical time have been Newtonian (absolute time) and Einsteinian (relativistic time). Physical time is distinguished from subjective, or internal time, which has the distinctive feature of phenomenality, i.e., there is something "it is like" to experience time; and this can differ greatly within and between individuals.

Present – A central category in the theory of time. Informally, the time that is *now*, framed by prior and potentially future events. Most theorists have resisted construing *the present* as a non-durational instant, simply because instants are fundamentally non-temporal: they cannot be added up to construct any interval *of time*. More widely, theorists have worked to develop a defensible theory of *the extended present*. These efforts have, however, struggled to defend subordinate notions of time slices, parts, stages, phases and intervals that can constitute the present.

Presentism – Broadly, the position that events, entities and objects exist (actually) in the present and that no prior (past) or future events, entities or objects exist. Events, entities and objects *come into* existence (either as an evolutionary, emergent or spontaneous pre-event) and then *go out* of existence. The structure of this temporal arc is contentiously debated. Future events are either epistemically indeterminate (they may exist, but we cannot know that they do) or they are merely ontologically conceivable or inconceivable, possible or impossible, probable or improbable.

Principle of Causal Closure – The ontological claim that every physical event that has an explanation has a physical explanation. Importantly, in accepting PCC it also is usually assumed that every physical event *does* have an explanation, which is a variation on another principle, the principle of sufficient reason.

Principle of Causal Configuration – The ontological claim that some neural structures, especially brain structures, are configured and potentiated by the states of their constituents which are, in turn, configured and potentiated by the syntax and content of the languages and informational processes in which they are 'written'. Such 'languages' can be construed as operating syntax, or code. In general, this principle represents a variety of monism where mental and physical events are ontologically conjoint but causally discriminable.

Proper Time – The elapsed time between two events as measured by a clock that passes through both events. This differs from coordinate time, especially at relativistic speeds. An accelerated clock will measure a smaller elapsed time than that measured by a clock that is not accelerated between the same two events.

Relational Time – First introduced by Leibniz, the theoretical position that 'time' designates nothing that is actual, and certainly nothing through which events and objects may be said to move. Rather, time is an abstraction, a construction, used to sequence and compare events. It is only 'substantial' only derivatively in the sense that it relates to real objects.

Relativistic Time – In relativity, time is one of four dimensions (one temporal, three spatial) of dynamically curved spacetime. In the Block Theory of the Universe time is fundamental where space and time 'behave' dynamically and relatively due to time dilation and the effects of gravitation.

Sequence, Sequential Difference – A sequence consists in one thing following another with which it is related in some ordered manner. One thing following another in a non-ordered or disordered manner does not constitute a sequence. Time, although commonly a property of sequences, is not an intrinsic property of them. A sequential difference consists in a different value, thing or property following another in an ordered manner.

Simultaneity – The property of two events occurring at the same time in a given inertial frame of reference. In relativistic physics, simultaneity can only be a relative property, not an absolute property of events.

Spacetime – In relativity, space and time are arrayed on a four dimensional continuum as an event field extended on all axes and where an infinite number of events (points in space at instants of time) can be designated. 'Past' and 'future' events are simply relativistic 'locations' in this event field defined by an arbitrarily selected origin of the axes.

Synchronicity – In Jungian psychology, a phenomenon where two or more events that are experienced at different times are also experienced as importantly – even if not causally – related.

Temporal – Of or relating to time.
Temporal Illusion – A distortion in the perception of external (physical) time. Time may be experienced as slowing down, stopping or accelerating as the timing and temporal order of external events are misperceived.

Temporal Parts – The parts or instances of a physical object, state or process that exist at different times. The theory of perdurantism, for example, maintains that the persistence of an object as a whole is the sum of its temporal parts.

Tensed (A-Theory) Theory of Time – The philosophical view that events characterized as past, present or future are fundamental and irreducible foundations of temporality. A-theorists often deny that past, present and future are equally real (as the tenseless theory of time contends). This view is generally consistent with the varieties presentism.

Tenseless (B-Theory) Theory of Time – The philosophical view that events can be described as "earlier than", "simultaneous with" or "later than" others, and that there is no need for verb tenses as A-theorists contend. B-theorists generally hold that past, the present and future are equally real, a position consistent with Relativity, eternalism and the block theory of the universe/time.

Time Asymmetry – The one-way directionality of physical (external) time. This effect is usually attributed to the second law of thermodynamics, the only time-asymmetric law in physics. This law is, however, not a conventional product of physical theory, operating more as a highly confirmed statistical principle. And it underwrites the very robust notion of entropy. Thus, this suggests that, though maximally improbable, time reversal is not impossible.

Time Slice – Instantaneous properties of persisting things that have temporal parts that do not themselves persist. The notion of temporal slices differs from the constructionist notion of temporal tags only in the view that temporal slices actually exist.

Time Symmetry – The theoretical symmetry of most physical laws under a time-reversal transformation. In general, within the laws of physics, the equations for physical processes are time-symmetric; that is, they work in both directions. So there is no 'arrow of time' in most laws of physics, i.e., they are time-reversible. Nonetheless, the very important second law of thermodynamics is arguably *time-asymmetric*, and arguably accounts for entropy and the direction and 'flow' of time.

Time Dilation – The temporal effect of relative motion whereby time 'runs' differently on different clocks, elapsing by different amounts for different observers travelling at different speeds relatively to each other. Thus, two clocks that were initially synchronized will not remain synchronized once they move relative to each other. This effect is virtually undetectable on earth yet will be significant at high relative speeds.

Truth-maker – Something that makes a statement, or the proposition expressed by that statement, true. Use of this concept rests on acceptance of the Truth-maker Principle which holds that no proposition can be 'barely' true. Rather, there must be something that makes a true proposition true such as a fact or state of affairs. Although this principle carries strong intuitive appeal it is difficult to find the truth-maker for a proposition like: "Mermaids do not exist."

Worldline – Represented by a curve, the path of a non-dimensional 'point' in spacetime.

Timelines

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