Passage and the Direction of Time

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Metaphysics » Lecture 3

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Passage and the River of Time

The Frozen Present?

[G]iven a complete tenseless description of reality, then what does the standard [A-theorist] need to add to the description to render it complete by his own lights? The answer is that he need add nothing beyond the fact that the given time t_0 is present, since everything else of tense-theoretic interest will follow from this fact and the tenseless facts. Thus all that the [A-theorist] need add to the anti-[A-theorist]'s 'static' account of the universe is the fact that a given time is present. And how could this solitary 'dynamic' fact be sufficient to account for the passage of time? Indeed, the [A-theorist]'s conception of time is compatible with a view in which reality is frozen on the present, at it were, with there being no genuine passage but merely different static relationships of things in the past and the future to things in the present. His conception of temporal reality, for all that he has said, may be as static or block-like as the [B-theorist]'s, the only difference lying in the fact that his block has a privileged 'center'. (Fine 2006: 405–6; see also Markosian 1993: 835, fn. 13)

Understanding Passage

- That **time passes** is one of the most basic features of time in our experience.
  - The present feels special, no doubt, but that is only part of the story; we also want to know how that 'special feeling' transfers from one moment to another, which is the phenomenon of passage.
- Fine's challenge to both main views of time we've considered is this: how to explain that **dynamic** aspect of time.
  - For the B-theorist, the challenge is how to explain the apparent passage of time in a block universe which is, in totality, **constant** over time.
  - For the A-theorist, the question is this. Do we need to add yet further structure to the block universe: a privileged moment, but also a special **process** for 'moving' that moment around?
- Before we can even begin to address these questions, we need a firmer grip on what passage is supposed to be.

The River of Time

- A standard metaphor:

  > we think of ourselves as stationary, watching time go by, just as we may stand on a bridge and watch leaves and sticks float down the stream underneath us. Events, we sometimes think, are like such leaves and sticks; they approach from the future, are momentarily in the present, and then recede further and further into the past. Thus instead of speaking of our advance through time we often speak of the flow of time. (Smart 1949: 483)

- Is the *naturalness* of this metaphor an indication that it is **more** than merely metaphorical?
- If it is mere metaphor, what is the underlying reality that makes the metaphor **apt**?
  - As, e.g., the metaphor that someone is *a giant in their field* is made apt by the size of their reputation.

The problem of flow

- Smart thinks the metaphor cannot be taken seriously:

  > we cannot talk about time as a river, about the flow of time, of our advance through time, or of the irreversibility of time without being in great danger of falling into absurdity. (Smart 1949: 485)

- The primary absurdity Smart considers is one deriving from the idea of **flow**: If something flows, it must have a **rate** of flow, but the idea of a rate of passage of time leads to absurdity.

What's the absurdity?

If time is a flowing river we must think of events taking time to float down this stream, and if we say 'time has flown faster today than it flew yesterday' we are saying that the stream flowed a greater distance today than it did in the same time yesterday. That is, we are postulating a second time-scale with respect to which the flow of events along the first time-dimension is measured. 'Today', *tomorrow*, *yesterday* become systematically ambiguous…. Furthermore, just as we thought of the first time-dimension as a stream, so will we want to think of the second time-dimension as a stream also; now the speed of flow of the second stream is a rate of change with respect to a third time-dimension, and so we can go on indefinitely postulating fresh streams without being any better satisfied. Sooner or later we shall have to stop thinking of time as a stream. (Smart 1949: 482)

Two problems of flow

- We see two problems identified by Smart:
  1. The problem of **reference**: which of the two temporal dimensions are referred to by our ordinary temporal expressions like *yesterday* or *March 12th*? If the first, then why have the second at all? If both, then ambiguity.
     - Though couldn't we **resolve** the ambiguity by introducing new terms — perhaps by subscripting — like we might resolve an ambiguity in *hot*, by introducing the new words *spicy* and *high temperature*?
  2. The problem of **regress**: won't we want any proper time dimension to flow? And won't that lead both to the absurdity of infinitely many time dimensions, and to the prior absurdity of making sense of **how fast** time flows?
- Note that Smart is not disputing that sometimes our **experience** of time prompts us to say things like *how time has flown!* But what this expresses, arguably, is just something like 'the last n hours have felt subjectively to me to have taken less than n hours'.
  - **Subjective judgment of the length of a time interval** is perfectly acceptable to the B-theory; if that is what passage ultimately is, there is no problem posed by passage.

Smart's diagnosis

- Smart uses these problems to motivate a discussion of what could lie behind the metaphor. He thinks the **overt** linguistic form of *past*-ascriptions resembles **genuine property ascriptions**; but this overt form is misleading:

  > if we think of events as changing, namely in respect of pastness, presentness, and futurity, we think of them as substances changing in a certain way. But if we substantialise events, we must, to preserve some semblance of consistency, spatialise time. 'Earlier than' becomes 'lower down the stream'. It is thus easy to see how there arises the illusion of time as a river down which events float. (Smart 1949: 493)

- Why do we do this? Some kind of **egocentric/anthropocentric** fallacy (Smart 1963: 131–42).
  - It's interesting to see Smart here criticize the 'spatializing' of time.

The A-Theory

- Recall that the A-theory includes the thesis that the A-properties — *pastness*, *presentness*, and *futurity* — are genuine absolute properties that events have, temporarily:

  A-property thesis ‘There really are A-properties; talk that appears to be about the possession of A-properties by times, events or things cannot be correctly analyzed in terms of B-relations among those entities’ (Markosian 1993: 832).

  > talk about A-properties does not merely describe some linguistic or mind-dependent phenomenon. That is, it seems to me that it is a genuine and objective fact about the world that 3:38 p.m., Thursday, March 19 is currently present, that various other times are currently past or future, and that, moreover, these things would be true even if there were no conscious beings and no language users in the world. (Markosian 1993: 835)

Smart and the A-theory

- The upshot of Smart's discussion is this: if we are A-theorists, we should be tempted to think that time **passes**, in the sense that events successively have the A-properties of first futurity, then presentness, and finally pastness:

  > times and events pass inexorably, over time, from being future to being present and then on to being more and more remotely past. (Markosian 1993: 836)

- How to understand the **explicitly temporal** language (*first*, *then*, *finally*) in that characterisation of passage?
- Smart says: we can understand it only in terms of **hypertime**, which brings problems in its wake.
- Two possible responses:
  1. Deny that the rate of passage is problematic;
  2. Deny that passage needs to be understood via the 'rate of flow' metaphor.
- Markosian takes option 1; he tries to make Smart's arguments clear and then suggests they can be resisted.

Arguing About the Rate of Passage

The First Argument Extracted from Smart: The Regress Argument

(1) If time flows or passes, then there is some second time-dimension with respect to which the passage of normal time is to be measured.
(2) If there is some second time-dimension with respect to which the passage of normal time is to be measured, then the second time-dimension must flow or pass.
(3) If the second time-dimension flows or passes, then there must be some third time-dimension with respect to which the passage of the second time-dimension is to be measured,… and so on *ad infinitum*.
(4) It's not the case that there is some third time-dimension with respect to which the passage of the second time-dimension is to be measured, … and so on *ad infinitum*.
(5) It's not the case that time flows or passes.
(Markosian 1993: 838)

Markosian's Response to the First Argument

- We can accept, I think, that if there is a second time-dimension, and if it is a genuinely temporal dimension, then there can be nothing **conceptually incoherent** about supposing it to flow.
- So even if it's not obligatory, it seems we get the **possibility** of the flow of a second time-dimension, and thus the possibility of the infinite regress.
- But, Markosian asks: **why think that there is a second time-dimension?**

  > Smart has said nothing yet to demonstrate that I am in any way committed to a second time-dimension with respect to which the passage of normal time is to be measured. (Markosian 1993: 838)

- Nothing in the A-theory requires that we accept premise (1)... **except** if it somehow follows from something else the A-theorist says.

Passage and Rates

- The purported origin of the second time-dimension lies in the claim that **if time passes, it must pass at some rate**, and in making that claim we 'raise a question that cannot be coherently answered' (Markosian 1993: 839), namely, the question of what that rate is.
  - If time flows, then that question must have a coherent answer.
  - Since it lacks a coherent answer, time does not flow.
- It is implicit in Smart's argument that there is no other way of coherently thinking about the passage of time than as a **rate of change with respect to a distinct temporal dimension**.
- So showing that rate leads to the regress is enough to show that time doesn't pass – unless you can give **some other conception** of what the rate of passage might be.

The Second Argument Extracted from Smart: the Rate Argument

(6) If it makes sense to say that time passes, then it makes sense to ask 'How fast does time pass?'.
(7) If it makes sense to ask 'How fast does time pass?', then it's possible for there to be a coherent answer to this question.
(8) It's not possible for there to be a coherent answer to this question.
(9) It doesn't make sense to say that time passes.
(Markosian 1993: 839)

- Or perhaps, instead of (8), we might have
  (10) The only coherent answer to this question is that time passes with respect to a second time dimension.
  - With this replacement, the conclusion (9) won't follow; but we will get premise (1) from the first argument, which yields in turn the conclusion (5) that time doesn't pass.

What is a Rate?

- Any rate involves the **comparison** of a change with some other change.
  - For example: 'meters per second' compares a change in meters travelled with a change in seconds elapsed.
- But which comparisons are legitimate? Three theories of rates:

  Any — A rate involves the comparison of one change with **any other change**, and **neither** charge need be essentially temporal.
- On the other hand, a more restricted conception says that to be a **rate**, a measure must involve the comparison of a change with **the pure passage of time**. Which changes are legitimate:

  Time-any — **Any change** can be meaningfully compared with the passage of time (including a comparison of the passage of time with itself).

  Time-some — **Only some *normal* changes** can be meaningfully compared with the passage of time.

Markosian's Response to the Second Argument I

- Three cases, depending on the three conceptions of change.
  - All **also motivate rejection** of premise (1) of the first argument, that there must be a second time-dimension. That premise rests on the idea that a change in time must be compared with a different elapsed time, and none of the three conceptions accept multiple time dimensions.
- Any rate comparison is **reversible**, on the Any conception: So we may give a coherent answer to the question, as follows:

  > If I tell you that Bikila is running at the rate of twelve miles per hour of the pure passage of time, for example, then I have also told you that the pure passage of time is flowing at the rate of one hour for every twelve miles run by Bikila (Markosian 1993: 842)

- This conception thus rejects premise (8) of the Rate argument.

Markosian's Response to the Second Argument II

- On the Time-any conception, we can make sense of arbitrary comparisons; so let's just compare the rate of passage of time with itself, getting the answer 'one hour per hour'.
  - Not **informative**, perhaps, but nevertheless **coherent**.
  - Again, premise (8) is false.
- On the Time-some conception, we can reject the request for a coherent answer. To ask for the rate at which time passes is to try to measure the rate of change of a non-normal change, and this is **conceptually incoherent**. We reject premise (6) of the second argument as making a **category mistake**.

> It is the paradigm, and, as such, it alone among changes cannot be measured. (Markosian 1993: 843)

Are these answers helpful?

- To the narrow charge **that no coherent answer can be given to the question, 'how fast does time pass?'**, Markosian has offered an answer.
- But showing that an answer is **coherent** is a low bar to reach:
  - Which answer is **true**?
  - Which answer do we have **evidence** for?
  - What does the true answer **really say** about the way things fundamentally are?
- It is a legitimate worry that Markosian's three candidate answers don't leave us any further illuminated on these subsequent questions — and these are the **important** questions about the metaphysics of passage.

Non-Temporal Rates

- The best candidate alternative conception of a rate is probably the **Any** conception: **there can be a rate of change with respect to any magnitude**.
- In fact we already have examples of this, both mundane and philosophical.
  - Consider a **gradient**: this is a rate of change of elevation (altitude) with respect to changes in displacement (motion along a path). We don't normally talk of gradient as a rate, but in our informal glosses we are tempted to do so, e.g., 'a gradient measures *how quickly* the road goes up when you are travelling along it' – this is a metaphorical use of *quickly*, true, but it shows that we can make sense of this is something rate-like.
  - Or consider rates of change with respect to Lewis' **personal time**, which is not a time dimension, but is similar enough to play the functional role of time. A time traveller might shrink with respect to external time, and grow with respect to personal time; then there is are two **growth rates** for them, only one of which is with respect to real external time.

Does Time Require ‘Genuine Passage’?

Option 2: Deny that passage needs to be understood using rates

- The 'river of time' metaphor led us to link time's passage with the idea that time flows.
- This was problematic for the standard A-theory, but is also problematic for the B-theorist.
  - Particularly a problem for the B-theorist who doesn't want to **gratuitously** revise our ordinary conception of the world, and so wants to make room for ordinary experience as of time's passing.
- So the question becomes: is there a way to understand passage on which the question of *how fast does it pass?* doesn't arise - perhaps a way that doesn't make use of the 'river' metaphor.
- This might be a conception of passage that is available to both A- and B-theorists.
- Fine's (2006) challenge yields this minimalist proposal:

M-Passage Time passes iff it's not frozen.

- Clearly this doesn't invoke rates of passage.

Making Sense of Frozen Time

- What is it for time to be stuck, or frozen? Here's one idea:

  Stuck Time is stuck iff (i) a certain moment t is present, and (ii) t was and will continue to be present.

- What does *t will continue to be present* mean? Look back to our analyses from last time, and we get something like this:

  (11) Time is stuck at t iff t is present and it is the case that t is present in the past, i.e., at a time earlier than the present.

- But (11) entails that *time is stuck* is **false** in the situations Fine and Markosian envisage.
  - *Time is stuck*, given the A-theoretic analysis of (11), entails that t is earlier than t (because t is present according to a moment earlier than t, and that can be true only if t is earlier than t). This is only possible if time is **circular**.

Passage and Tense

- Hence on plausible versions of the A-theory, therefore, time will not be stuck: it is absolutely true as of now that other times **will be** present, and other times **were** present:

  > it is part of [A-theorist's] view that the light of presentness is not 'frozen', since their view entails that other, future times will be present, and that other, past times have been present. What more could it conceivably mean for the light not be frozen. (Dorr 2013: §1.1)

- If this is right, the A-theorist need not address Smart's challenge. If all you need to have passage is for *this moment won't always be present* to come out true, then premises (1) and (6) of Smart's arguments are both false.
- There is M-Passage in our world, even on the standard A-theory.

B-Theoretic Passage

- While the A-theorist gives a distinctive A-theoretic gloss on (11), note that the tensed expressions involved in it can be understood by the B-theorist too.
  - They will also deny that time is stuck, and resist arguments against the B-theory on the basis of its alleged lack of dynamicity.
  - The B-theory says that *time is stuck* is true of a moment only if that moment is at all moments earlier than itself, and that will be false on any view on which there is more than one time.
- As Deng puts it, for the eternalist, the truth of *time passes* need involve nothing more than 'that there is more than one time and that they succeed one another' (2012: 30).
  - I.e., there is M-passage on the B-theory too.
- If M-passage is just **succession**, we can have passage without the metaphorical rivers, and without the problems that arise from taking that metaphor **too seriously**.
- A residual problem: it doesn't **feel** like mere succession; time does seem to flow at varying rates, not just one moment after another. So even if the metaphysics of passage is sorted, the **experience** as of passage still needs some further explanation.

Fundamental Direction

Flow and Direction

- One further aspect of the metaphor of the river of time is that its flow has an apparent **direction** – from past, to future. As we bob along the river of time, we pass events that were once future, then become past.
- This isn't merely an artefact of passage. Time itself seems to have a direction, in at least the following sense: there is some **asymmetry** between past and future.
- The claim that time has a privileged direction in fact seems to be part of the orthodox B-theory, when characterised as the thesis that the fundamental temporal relations are *earlier than* and *later than*.
  - These are directed relations. Compare the distinction between the relations *next to* and *to the left of* - the former is undirected, the latter directed.

Passage, Flow, and Direction

> [T]he passage of time is an intrinsic asymmetry in the structure of space-time itself, an asymmetry that has no spatial counterpart and is metaphysically independent of the material contents of space-time. It is independent, for example, of the entropy gradient of the universe. …
> Except in a metaphorical sense, time does not move or flow. Rivers flow and locomotives move. Of course, rivers only flow and locomotives only move because time passes. … The Mississippi flows from north to the south, and the locomotive goes from, say, New York to Chicago. The direction of the flow or motion is dependent on the direction of the passage of time. Change and flow and motion all presuppose the passage of time, so the reality of change is bound up with the reality of time's passage, but we will avoid saying that time itself changes or flows (Maudlin 2002: 259–60)

- Maudlin seems to be offering an **alternative definition** of passage: that time passes iff it has a direction.
  - This is terminologically misleading; Maudlin isn't really an A-theorist.

Fundamentalism and Reductionism

- Whether a moment of time is occupied by an event, and what the character of that event is, is an **extrinsic** feature of that moment.
  - An extrinsic feature is one that duplicates needn't share – e.g., the property *being 1m from a banana* is one that I might have, but a copy of me needn't have.
- Maudlin argues that the direction of time is an 'intrinsic asymmetry': this would be an asymmetry that inheres in the structure of time itself, rather than in the contents of time.
  - *Illustration*: if there is, between any two moments, another, then time is intrinsically **dense** - any duplicate temporal structure would also be dense. But there need not be an event between any two events, so the **contents of time** need not be dense even if time is.
  - By contrast, suppose we accept the thesis of **progress**: earlier moments are worse than later moments. But this is an extrinsic asymmetry; it relies on what is happening in time, not on the structure of time itself.
- So Maudlin is setting himself against this thesis:

Reductionism The asymmetry of time derives from, or is grounded in, an asymmetry in the contents of time.

Fundamentalism: Intuitive appeal

The passage of time … is the asymmetry that grounds the distinction between sequences which run from past to future and sequences which run from future to past. Consider, for example, the sequence of events that makes up an asteroid travelling from the vicinity of Mars to the vicinity of the Earth, as opposed to the sequence that makes up an asteroid moving from the vicinity of Earth to that of Mars. These sequences might be "matched", in the sense that to every event in the one there corresponds an event in the other which has the same bodies in the same spatial arrangement. … Still, going from Mars to Earth is not the same as going from Earth to Mars. The difference, if you will, is how these sequences of states are oriented with respect to the passage of time. If the asteroid gets closer to Earth as time passes, then the asteroid is going in one direction, if it gets farther it is going in the other direction. (Maudlin 2008: 108)

Fundamentalism and Possibility

- If temporal direction is fundamental, then it doesn't depend on any other features of reality:

  > if it exists, a temporal orientation is an intrinsic feature of space-time which does not need to be and cannot be reduced to nontemporal features….
  > (Earman 1974: 20)

- As a result, the direction of time is only **contingently** associated with any other features of reality, such as which events happen to occur and what they are like.
- Once we specify which moments the universe contains, and what happens at those moments, there is – if fundamentalism is correct – a **further** question: which are earlier and which later?
  - Nothing in the information we have about the contents of the universe settles the answer to that further question.

Puzzles About Fundamentalism

- A central problem for fundamentalism: what **physical significance** does the direction of time have?
- If fundamentalism is right, to specify a possible situation (to 'write the book of the world', completely describing all it contains), it is not enough to specify all the asymmetries in what happens, asymmetries in what causally depends on what, asymmetries in knowledge, etc. We also need to say in which direction processes 'go'.
- The problem is: why would we care about temporal direction once we've already specified all the other interesting physical asymmetries **in** time? Why would anyone be interested in an asymmetry which is independent of the material contents of spacetime?
  - This is what Price calls the 'open question argument' (Price 2011: 295) – though the moral is actually the reverse of Moore's open question challenge to moral naturalism.

The Objection from 'Doppelgängers'

[T]he observation is made that we [accept] Time Reversal Invariance …: for physically possible sequence of states $T_0, T_1, \ldots, T_N$ running from past to future, there is physically possible sequence $T_N^*, \ldots, T_1^*, T_0^*$ running from past to future. For example, given the actual sequence of physical states of your body over the last ten minutes, the time-reversed sequence of time-reversed states is also physically possible. Somewhere on some other planet … some such sequence could exist, unproblematically time reversed relative to the sequence of states which make you up. Let's call this sequence of states your *time-reversed Doppelgänger*. But, the objection goes, there is an obvious one-to-one mapping from the Doppelgänger's states to yours. So the Doppelgänger would surely have qualitatively identical experiences to yours, only with the whole process oppositely oriented in time. (Maudlin 2002: 271)

Responding to the Doppelgänger objection

[G]iven the physical description of the Doppelgänger that we have, what can we conclude about its mental state? … we would have no reason whatsoever to believe that the Doppelgänger has a mental state at all. After all, the physical processes going on the Doppelgänger's brain* are quite unlike the processes going on in a normal brain. Nerve impulses* do not travel along dendrites to the cell body, which then fires a pulse out along the axon. Rather, pulses travel up the axon* to the cell body*, which (in a rather unpredictable way) sends pulses out along the dendrite*s. The visual system* of the Doppelgänger is also quite unusual: rather than absorbing light from the environment, the retina*s emit light out into the environment. … … We have *no reason whatsoever* to suppose that any mental state at all would be associated with the physical processes in the Doppelgänger. (Maudlin 2002: 272–73)

‘Earlier than’ or ‘Causally prior to’?

- Maudlin is arguing that the time-reversed Doppelgänger would be distinct from the ‘normal’ version, even though it is an instant-by-instant duplicate.
- This however seems to be smuggling in an assumptions about the contents of time: **that when we reverse the time order, we also reverse the causal order**.
  - In the ordinary case, incident light **causes** a change in the retinal state that we call *absorption*. If we reverse the time order and keep the causal order fixed, this would **still** be true of the Doppelgänger: their retinas would absorb light impulses (though, unbeknownst to them, the incident light comes after the absorption).
  - But Maudlin thinks otherwise – that in the Doppelgänger, the retina **emits** light. Again, *emits* is a causal word, so Maudlin appears to be presupposing that the reverse of temporal order is accompanied by a reverse in the causal order.
- The **functionalist** thesis that mental phenomenology is **grounded** in the **causal relations** among brain states is widely accepted. So it is easy to see why if Maudlin thinks the causal structure is reversed, that might not give rise to any way of assigning coherent mental states to the Doppelgänger.
- But – and this is the key point – causal relations hold among events, the **contents** of time. Causation is not intrinsic to the structure of time; it is **illegitimate** for the fundamentalist to suppose that temporal reversals result in causal reversals.

Temporal Functionalism

- Maudlin might respond: *the way that mental states depend on ('supervene on') brain states involves the* ***external temporal environment*** *in such a way that this Doppelgänger, whose perceptual 'beliefs' come* ***earlier*** *than the events which are nominally their content, whose 'pains'* ***precede*** *painful events, etc., does not have mental states like ours*.
- But this is not plausible.
  - Maudlin's **temporal** functionalism says that part of what makes a state a belief is that it is **later** than the event that it is about.
  - But a plausible functionalism says that part of what makes a state a belief is that it is **an effect** of the event that it is about.
  - Drive a wedge between these – e.g., create a state that is the effect of an event, but precedes it – and I think such a state could still be a belief, even though it doesn't have the normal time-ordering (Price 2011: 300). (Consider e.g., the mental states of a backwards time traveller.)
- And the **causal structure** of the Doppelgänger's brain states is just like ours; so presumably it would have beliefs, experiences, etc. just like ours.
- Fundamental temporal order just isn't plausibly of **independent** interest to us.

A more charitable reading…

- Perhaps Maudlin does mean to individuate mental states causally, like plausible varieties of functionalism. He might turn out to be an idiosyncratic reductionist:
  (12) The direction of causation is fundamental, and 'is metaphysically independent of the material contents of space-time'; and
  (13) The direction of time is to be **identified** with the direction of causation.
- Both theses face objections.
  - Causation is a paradigm **physical** relation; how could any plausible theory of causation claim that which events are causes is 'independent' of the total distribution of physical events (Price 2011: 296–97)? Moreover, there are arguments to the effect that causation **isn't** fundamental (Eagle 2007).
  - **Backwards causation** may be non-actual, but hardly seems impossible (think about backwards time travel cases).

Reductionism about Temporal Direction

Reduction of Time Direction to Asymmetries in Time

- If we are to avoid the open question argument – namely, that it is a open question why we should **care** about the direction of time — we need to link temporal orientation to something in the pattern of events in time that could have significance for us.
- One very natural thought: the block universe differs in what happens at each 'end': and that one end, in virtue of what happens at it, is to be designated the **initial** state.
- A few representative asymmetries:
  1. An asymmetry of **memories and records**; the direction which we have good records of is earlier than the other direction.
  2. There is an asymmetry of **causation/explanation**; the initial condition must be that state which supports that asymmetry.
  3. There is an asymmetry of **thermodynamics**; many macroscopic physical processes are irreversible. The thermodynamic explanation of irreversibility invokes a temporally asymmetric law: that in a closed system, **entropy** never decreases. The lower entropy direction is the past. (Perhaps the other asymmetries are explained by this: Callender (2021), §3.)
- Let's see if any of these can ground the direction of time.

The Asymmetry of Memory

> [T]here are photographs, fossil records, footprints in sand, and innumerable other such species of traces of the past, and yet nothing at all comparable in the case of the future. We know a great deal about past history and yet the future is obscure to us. (Smart 1963: 142)

- There are widespread signs of one direction of time around us; very few reliable signs of the other.
- The direction which has left traces is the past: ‘ “past” means … something like *the direction in which we remember things*’ (Price 2011: §3.9.3).

The Asymmetry of Causation and Causal Explanation

- These traces are **effects**. So the asymmetry of memory looks linked to an asymmetry of causation, and of causal explanation. (The traces are there *because* of the events they indicate.)
- But there are also contemporaneous traces: the barometer reads 'storm', which reliably indicates unsettled weather.
- In this example, we have correlation without causation; their correlation is explained by a **common cause** (in this case, a drop in air pressure).
  - But two correlated events are not associated with a common effect! The barometer causes quite different things than the storm.
- This is what Reichenbach (1956) called the **fork asymmetry** (Horwich 1987: 71–76).
- In turn, Horwich tries to explain the fork asymmetry by a **cosmological asymmetry**: the fact that the universe started with a Big Bang entails that the initial conditions are **random**: the contents of regions of the universe are not generally correlated with the contents of disjoint regions. So if we find a correlation, we can deduce the involvement of a common cause: 'for an uncaused correlation of A and B could occur only if their causal antecedents were correlated; and this would entail a correlation among initial conditions…' (Horwich 1987: 74).

Thermodynamics

Our everyday experience is largely of physical processes that occur in only one direction in time. A warm cup of coffee, left on its own in a cooler room, will cool down during the day, not grow gradually warmer. A box of gas, opened up in one corner of a room, will expand to fill the volume of the room; an initially spread-out gas won't contract to one tiny corner. …
More, it seems to be a lawlike fact that popsicles melt and gases expand to fill their containers. These generalizations support counterfactuals, they are used in successful explanations and predictions, and so on. They seem to satisfy any criteria you like for lawfulness; they surely don't seem accidental.…
And, in fact, there is a physical law that describes these processes: the second law of thermodynamics. This law says that a physical quantity we can define for all these systems, the entropy, never decreases. (North 2011: 313–14)

The Asymmetry of Entropy

- The **entropy** of a system is something like a measure of its **disorder**, how randomly arranged its constituents are.
- The **second law of thermodynamics** says: in a closed system – including the universe as a whole – entropy always increases over time.
  - This is obviously a temporal asymmetry in the distribution of entropy.
- This asymmetry doesn't derive from the laws of motion alone, which are **time-symmetric**. So a given state could equally have arisen from a lower or a higher entropy prior state.
- Instead, to explain the thermodynamic asymmetry, we need to couple the laws of motion with a postulate about **boundary conditions**: namely that the universe is, at one point, in a very low entropy state.
  - This is the **past hypotheses** (Albert 2000; North 2011: §6.1).
- In worlds like ours, there is agreement between different sub-systems of the universe on the location of this entropic asymmetry (so that the low entropy state can be used to **orient** the whole of spacetime);
- Is this true (Price 2011: §§3.1, 3.9.3)? We'll return to this below

A Unified Direction?

- These several sources of temporal asymmetry tend to align; that suggests that perhaps **one of them** grounds the others.
- Most people have thought the statistical mechanical explanation of entropy increase - the postulation of a low entropy initial condition – is the best unifying candidate (Callender 2021: §3.2).
- On this view, our universe started out in a very improbable condition. Almost all of the precise microstates compatible with that condition lead, via the laws of motion, to a higher entropy state, because highly organised/low entropy states are very **uncommon**. (There are many more ways to disorder some things than to order them.) So it is almost certain that entropy will increase.
- This is also supposed to explain, or at least make possible, the asymmetries of causation and of traces.
  - Consider traces. Almost all possible states of a thermodynamic system are high entropy. Without the past hypothesis, if we see some local bit of order, probabilities alone suggest that it is likely to be a **random fluctuation** (North 2011: 323). So if that local piece of order is a reliable sign of even more orderly situation, then we need something like the past hypothesis to block the sceptical inference; there can be traces **only if** we have low entropy boundary conditions (North 2011: 324–26).

Problems for Reductionism

- The reductionist asserts what the fundamentalist denies: namely, that some asymmetry **in** time must hold, because it grounds the asymmetry **of** time.
  - To take the entropy theory: it is not just against the laws of thermodynamics – and so physically impossible – that entropy decrease towards the future in any systematic way: it is in fact **metaphysically impossible** that entropy decrease towards the future, because the future **just is** the direction of global entropy increase.
- The problem is that this just doesn't seem to be true. A scenario constructed by using our actual reference fixing description of the past – something like *the direction we remember, and in which entropy decreases* – which involves that very direction being the direction of entropy decrease, seems perfectly **coherent**.

Coherent Possibilities

- Distinguish: the coherent stipulation *the direction in which, actually, entropy decreases, might have been the direction in which entropy could have increased* from the incoherent *it might have been that the direction in which entropy decreases was the direction in which entropy increases*.
- Parallel: *the person who is actually PM might not have been* vs. *it might have been that the person who is PM isn't PM*.
- It simply doesn't seem to be true that *the past* is **synonymous with** *the direction of low entropy*; there is no reduction here.

No Direction?

Local or Global?

- The reductionist relies on a very strong and untested assumption: that these asymmetries in the contents of time are **global**, and ground the global orientation of the universe – the assumption that ***the*** *direction of time* is a coherent definite description.
- But in fact many of these asymmetries are merely **local**.
- There are from time to time random **fluctuations** away from high entropy conditions. These are improbable but nevertheless possible.
- Near one of these fluctuations, the global temporal direction won't line up with the direction of entropy increase, for a time. This is perfectly possible, but is gives a concrete example of the failure of the reduction here; there is local direction, but no global direction, even though the universe is globally entropically asymmetric.

> this proposal to tie low entropy boundary conditions with the intuitive idea of the past… leads to a picture in which the direction of time is not fundamental. At best, it is something we have 'locally', in appropriate proximity to non-equilibrium regions. (Price 2011: §3.9.3)

Boltzmann's proposal

- We've seen difficulties with both reductionism and fundamentalism. We might reject both, in favour of the claim that **time has no direction**.

  > For the universe, the two directions of time are indistinguishable, just as in space there is no up and down. However, just as at a particular place on the earth's surface we call 'down' the direction toward the center of the earth, so will a living being in a particular time interval of such a single world distinguish the direction of time toward the less probable state from the opposite direction (the former toward the past, the latter towards the future). (Boltzmann 1898: 447)

The C-theory and perspectivalism

- Boltzmann notes that inhabitants of our world would **call** the entropy decrease direction *the past*, but denies that there is any objective significance to this **terminological** choice (Price 2011: 283).
- Boltzmann, and Price, endorse McTaggart's **C-theory**: time has an order, but not a direction, unless we impose it from a particular **local perspective**.
- Here's how this true **block universe** might be constructed. We have a set of moments M, and defined on that set a 3-place relation of **temporal betweenness**, *y is temporally between x and z*. We have a C-series if the following holds:

  (Linearity) For any distinct x, y, and z, either x is between y and z, or y is between x and z, or z is between x and y.
- This generates an ordered structure on the set of moments, but no privileged direction.
- We can locally assign a past/future orientation on an ordered set of moments, perhaps derived from the local entropy gradient; but this doesn't require that it be extended to the whole universe.

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