Time and Ontology

Antony Galton

The University of Exeter, UK

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Two Examples

Most modern ontologies include entities called "times" or something similar, but they differ in where they include them in their taxonomy. For example:

1. **BFO** **Temporal instant** and **temporal interval** are subclasses of **temporal region**, which is itself a subclass of **occurrent**, alongside **spatiotemporal region**, **process**, and **process boundary**.
   As occurrents, BFO times *occur*—they are concrete, not abstract.
2. **DOLCE** **Time interval** is a subclass of **temporal region** which is a subclass of **region**, which is itself a subclass of **abstract**, alongside **set**, **fact**, etc.
   So DOLCE times are abstract, not concrete.

Times as dependent entities

Times are *when events happen* so a definition of times must account for how times are related to the events that happen at them.

One possibility is to *define* times in terms of events: this makes times *dependent entities*.

Two natural ways of doing this are:

1. **Abstract conception.** A time is a *simultaneity class*, a maximal set of mutually simultaneous events. This makes times abstract entities, as in DOLCE.
2. **Concrete conception.** A time is the *mereological sum* of a maximal collection of mutually simultaneous events. This makes times occurrents, as in BFO.

Abstract conception: Times as simultaneity classes

A time is a maximal set of mutually simultaneous events.

Mathematically, a simultaneity class is an **equivalence class** under the **equivalence relation** of simultaneity defined on events.

If simultaneity of **point events** is given, e.g. as a primitive relation, then **extended events** are simultaneous if their start points are simultaneous and their end points are simultaneous.

The **time of an event** is now simply the simultaneity class of which it is a member.

Concrete conception: Times as sums of events

A time is the mereological sum of a maximal set of mutually simultaneous events.

In this case an event is a *part* of the time at which it occurs.

The time is dependent on the events which are its parts: the time occurs by virtue of the events' occurring.

Further considerations

1. If times are dependent on events, *relations* between times (e.g., *before*, *after*, *overlap*, *immediate succession*) must be defined in terms of corresponding relations between events.
2. Defining times in terms of simultaneity presupposes a coherent and consistent conception of simultaneity. This is available as an absolute relation within Newtonian space-time, but in Special Relativity it can only be defined relative to the state of motion of an observer—and even then is of dubious physical significance.

Times as independent entities

Another possibility: Times are independent entities not defined in terms of anything else.

They could still be either concrete or abstract (unless you think abstract entities are necessarily dependent on concrete ones).

Events are related to times by a primitive "time of" relation:

t is the time of event e

Temporal relations amongst events are defined in terms of corresponding relations amongst times.

Instants and Intervals

On any conception of time we can consider what different *kinds* of times there are, and how they are related.

Most ontologies include both **time instants** (of zero duration) and **time intervals** (of positive duration)—but the terminology varies:

- In BFO a **temporal interval** is the time of a **process**, whereas a **temporal instant** is the time of a **process boundary**.
- In GFO these are called **chronoids** and **time boundaries** respectively.

Instants and intervals are obviously related to each other, but how?

"Bottom-up" vs "Top-down" Conceptions of Time

Our conceptions of time include both **time as a whole**—the "time line"—and **elements of time**, that is, instants and/or intervals.

How is time as a whole related to its elements?

- **Bottom-up view:** Temporal elements are primary, time as a whole is built up from them.
- **Top-down view:** Time as a whole is primary, its elements are obtained by "carving up" time.

Both views come in a variety of "flavours".

Bottom-up I: Time as a Mathematical Continuum

This is the "Standard Model".

- The basic elements are non-denumerably many dimensionless **instants**, ordered like the real numbers.
- An **interval** is determined by the instants falling within it. It could be either the *set* of those instants, or their *sum*.

The Standard Model is extremely useful, but is metaphysically problematic:

1. It requires a **non-denumerable actual infinity** of instants.
2. It implies the existence of distinctions (e.g., between **open** and **closed** intervals) for which there is no empirical basis.
3. It does not explain how intervals have different **lengths**, since all intervals contain the same number of instants.

Bottom-up II: Discrete Time

- The basic elements are **atomic intervals**: intervals of minimal length, containing no subintervals.
- Each interval has an immediate predecessor and an immediate successor (integer-like ordering).
- Any interval is the sum of a sequence of contiguous atomic intervals.
- The length of an interval is determined by the number of atomic subintervals it contains.

Discrete time can be useful for modelling particular kinds of situation (e.g., clock-cycle in a digital computer). It may or may not be a fundamental feature of physical reality.

Top-down I: Aristotelian Time

- The parts of time are determined by events that occur.
- The parts of time are **intervals**, which are the times of extended events.
- An **instant** is not a part of time but a dividing point, marked out by e.g., the beginning or ending of an extended event.
- Time is not "made of" instants: an extended interval cannot be constructed from the points where it can be divided.

Top-down II: No-instants Model

- Instants are idealizations with no empirical support: we can only experience or measure intervals.
- But we can distinguish intervals whose duration we can determine and intervals that are too short for this.
- "Instantaneous" events are events whose duration is too short to register.
- This is relative to the "temporal resolution" of our measuring apparatus.

Past, Present, and Future

Theories of time are classified as A or B theories, depending on their treatment of **tenses** (past, present, and future), and **time-relations** (simultaneity and succession).

- **A-theory:** Tenses are objectively real, and determine the time-relations, e.g., '*a* before *b*' means 'when *b* is present, *a* is past'. What is objectively real is always changing.
- **B-theory:** Tenses are subjective; the objectively real features of time are time-relations, which do not change. Uttered at *t*, '*a* is past' means 'The time of *a* is before *t*'.

A-theory is often associated with **Presentism** ("Only what is present exists"), whereas B-theory is associated with **Eternalism** ("All times exist equally"). But A-theories can be eternalistic (the "moving spotlight") or semi-eternalistic (the "growing block").

Can an Ontology have an A-theory of time?

- A-theories are generally regarded as ruled out by the Theory of Relativity, in which simultaneity (and hence 'the present') is at best relative to an observer's state of motion.
- Hence an ontology that aims to capture observer-independent facts about the world seems committed to a B-theory of time.
- An ontology that aims to capture elements of subjective experience may be more hospitable to an A-theory.
- In an A-theory the facts are constantly changing, so an A-theory ontology must be constantly updated in real time.
- But an ontology that only seeks to capture general truths as opposed to particular facts could be non-committal between A- and B-theories.

There is MUCH more to say _____

_____ **but no time to say it.**

Thank you for listening!