

The Ontology of Time and Process

Part III: Processes and Events in BFO and DOLCE

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BFO: Basic Formal Ontology

References:

- ▶ Barry Smith (et al), *Basic Formal Ontology 2.0: Specification and User's Guide*, 2015. Accessible from <https://github.com/BFO-ontology/BFO>.
- ▶ Robert Arp, Barry Smith, and Andrew D. Spear. *Building Ontologies with Basic Formal Ontology*. MIT Press, 2015.

BFO defines ' p is a process' to mean:

p is an occurrent that has temporal proper parts and for some time t , p specifically depends on some material entity at t .

with examples such as

- ▶ the life of an organism
- ▶ a process of sleeping
- ▶ a process of cell-division
- ▶ a beating of the heart
- ▶ a process of meiosis
- ▶ the course of a disease
- ▶ the flight of a bird
- ▶ your process of aging

These are all *particulars*, e.g., a sleeping by a particular person on a particular occasion.

A BFO process occupies a spatio-temporal region:

- ▶ The life of an organism occupies a “long thin” spatio-temporal “worm”. For each time t within the temporal extent of the worm, the 3D cross-section of the worm at t is the spatial region occupied by the organism at t .
- ▶ A process of sleeping is a proper part of the life of some organism: it is a maximal temporal part of the worm for which, at each moment during its temporal extent, the organism is asleep.
- ▶ A beating of the heart could be a single heartbeat (a single cycle of contraction and relaxation of the heart muscle), or the extended heartbeat process that is coterminous with the entire lifetime of the organism. The latter has numerous proper parts similar to the former.

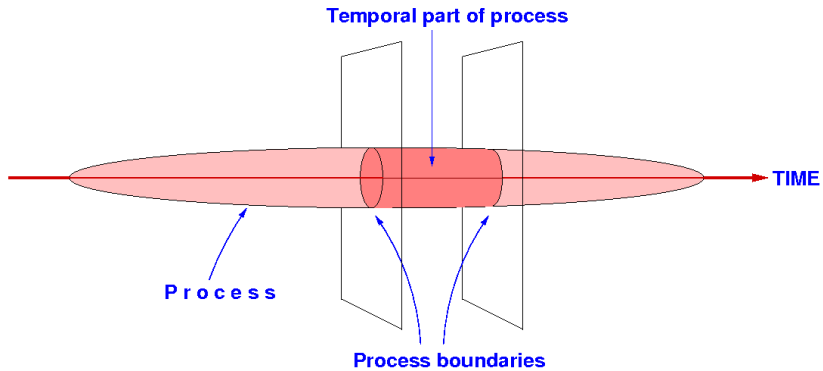
In addition to processes, BFO includes **process-boundaries**:

A process-boundary is a temporal part of a process which has no proper temporal parts itself.

Hence, a process-boundary is not a process.

Process boundaries include

- ▶ **beginnings** and **endings** of processes
- ▶ **internal boundaries** of processes, i.e., any minimal temporal cross-section within the interior of a process.



BFO has no separate category of *event*. For BFO **there is no difference between processes and events.**

A BFO process: the making of a (particular) apple pie

Processes that are proper parts of this one include:

- ▶ the cutting up of the apples
- ▶ the preparation of the pastry
- ▶ the assembling of the pie
- ▶ the baking of the pie

The first of these has as proper parts the cutting up of each individual apple; each of these has as proper parts individual knife-strokes.

Etc., etc.

In BFO, **occurrents do not have qualities**.

There are no such entities as:

- ▶ the speed of this movement
- ▶ the direction of this movement
- ▶ the loudness of this music

Hence **occurrents cannot change**, since there are no qualities for them to change with respect to. So a movement's getting faster, or changing direction, or the music's getting louder, are not themselves processes.

How can we express, in BFO, the fact that a certain movement is gets faster?

According to the BFO specification, we should say something like

Motion m is an instance of motion-at-speed- v_1 at t_1 , and motion m is an instance of motion-at-speed- v_2 at t_2 , where $t_1 < t_2$ and $v_1 < v_2$.

But it is not made clear what it means to say that one motion instance can be an instance of different motion universals at different times, since this seems to imply that a motion instance can change.

A better way to refer to the changing speed of a motion in BFO might be:

Motion m has temporal proper parts m_1 and m_2 , existing on intervals i_1 and i_2 respectively, such that m_1 is an instance of motion-with-average-speed- v_1 and m_2 is an instance of motion-with-average-speed- v_2 , where $i_1 < i_2$ and $v_1 < v_2$.

(But talk of the instantaneous speed of a moving object has to invoke the idea of a limit, as in the differential calculus, assigning speeds to process-boundaries that are proper parts of the motion process, but not processes themselves.)

DOLCE: Descriptive Ontology for Linguistic and Cognitive Engineering

Reference:

- ▶ C. Masolo, S. Borgo, A. Gangemi, N. Guarino, and A. Oltramari. *WonderWeb deliverable D18*. Technical report, Laboratory for Applied Ontology, ISTC-CNS, Trento, Italy, 2003.

BFO

Aims to provide a set of tools for directly describing the mind-independent reality that is the focus of scientific investigations.

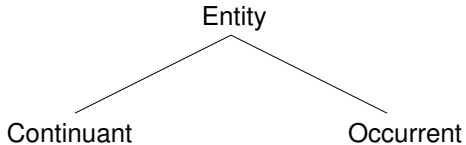
A category stands or falls on whether it successfully picks out a class of real-world entities united by possession of some shared set of objective properties.

DOLCE

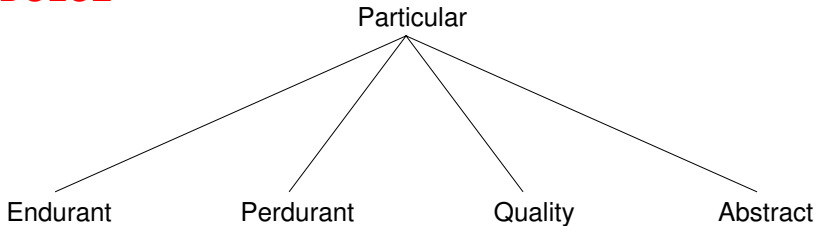
Aims to systematise the categories employed in human conceptualisations of the world.

A category represents some concept under which humans might group entities in accordance with some cognitively determined principle of classification, which may or may not correspond to an objective feature of reality.

BFO



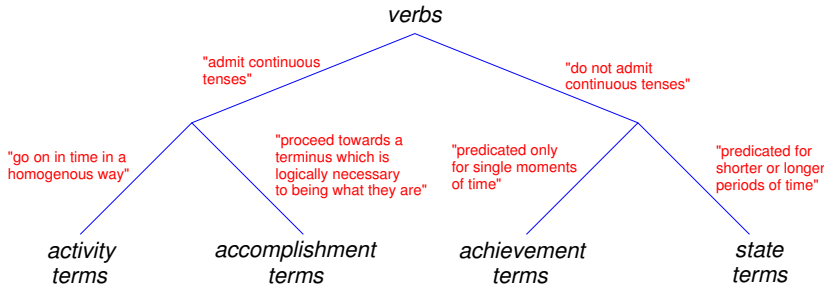
DOLCE



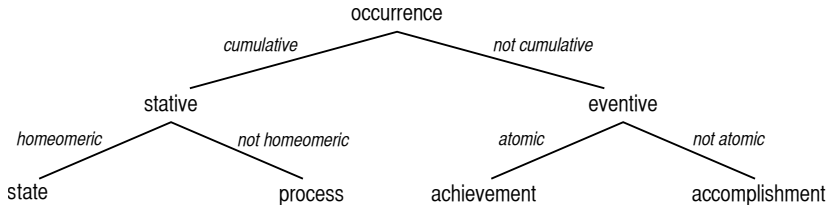
- ▶ In DOLCE, the part-whole relation for endurants is time-indexed, but the part-whole relation for perdurants is not. BFO handles this using two relations *x* *continuant-part-of* *y* *at t* and *z* *occurrent-part-of-y*.
- ▶ Endurants are primarily located in space, and inherit their temporal properties from the perdurants in which they participate. Perdurants are primarily located in time, and inherit their spatial properties from the endurants which participate in them.
- ▶ In BFO, *has_participant* is a temporally-indexed relation between occurrents and continuants; an occurrent is specifically dependent on the continuants to which it bears that relation. In DOLCE, *participates in (PC)* is a temporally-indexed relation between continuants and occurrents

The Vendler Classification

Zeno Vendler, 'Verbs and Times'. In *Linguistics and Philosophy*, 1967.



Classification of Perdurants in DOLCE



cumulative occurrence-type: “holds of the mereological sum of two of its instances” .

homeomeric occurrence: “all its temporal parts are described *by the very expression* used for the whole occurrence”

Cumulativity and Homeomericity

These are properties of *occurrence types*, not of individual occurrences:

- ▶ Occurrence type T is cumulative so long as, for any two instances x and y of type T , the mereological sum $x + y$ is also an instance of type T .
- ▶ Occurrence type T is homoeomeric so long as, for each individual instance x of type T , every temporal proper part of x is also an instance of type T .

It follows that the terms “stative”, “eventive”, “state”, “process”, “achievement” and “accomplishment” used in the DOLCE classification of perdurants apply not to occurrences *per se* but to occurrences *under a description*.

Example: **The flight of a plane from London to New York.**

Call this occurrence F . We can describe it in different ways:

- (a) *The plane flies.*
- (b) *The plane flies from London to New York.*

Let F_1 and F_2 be two occurrences to each of which (a) and (b) apply. Then (a), but not (b), also applies to their mereological sum $F_1 + F_2$.

Hence description (a) is cumulative but description (b) is not.

Is (a) homeomeric? Nearly, since it applies to any temporally extended proper temporal part of F ; but it does not apply to *atomic* temporal parts of F . So (a) is not homeomeric, and hence it describes a **process**.

Is (b) atomic? No! Any flight from London to New York must take up an extended temporal interval. Hence (b) describes an **accomplishment**.

Example (continued)

A third form of sentence we can use in English is

(c) *The plane is flying.*

Like (a) (*The plane flies*), this is cumulative. Unlike (a) it is also homeomeric, since it applies to the temporally atomic temporal parts of any occurrence it applies to. Hence (c) describes a **state**.

Now consider

(d) *The plane lands.*

Like (b) (*The plane flies from London to New York*), this is not cumulative. But at least on one interpretation (equivalent to *The plane touches down*) it is atomic: it applies to occurrences which are not temporally extended. Hence (d) describes an **achievement**.

BFO vs DOLCE Revisited

It thus appears that:

- ▶ A BFO occurrent is just the contents of some delineated but temporally extended portion of space-time. Its properties do not depend on how it is described.
- ▶ A DOLCE occurrence is the contents of some portion of space-time together with a description, i.e., *qua* instance of some class. Its properties depend both on the portion of space-time and the class to which it is assigned by the description.

DOLCE is thus **multiplicativist**: there can be more than one occurrence occupying exactly the same portion of space-time. BFO by contrast is **unitarist**: there cannot be more than one occurrent occupying exactly the same portion of space-time.