The Ontology of States, Processes, and Events

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What is a Process?

*Processes are repeatable behaviours whose occurrences cause continuants to undergo change.*

A. Özgövde and M. Grüninger,
'Functional process relations in bio-ontologies' (FOIS 2010):
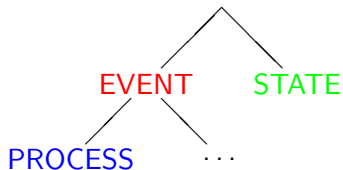
What is a Process?

Processes are repeatable behaviours whose occurrences cause continuants to undergo change.

A. Özgövde and M. Grüninger,
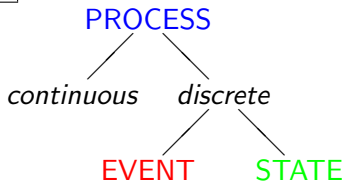'Functional process relations in bio-ontologies' (FOIS 2010):
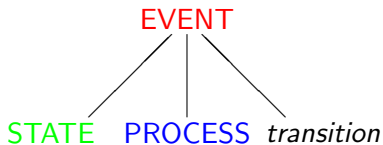
. . . but not everybody sees it that way
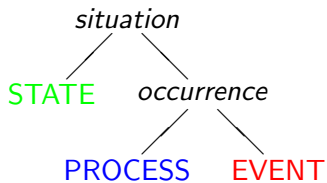
Problem: How can we fit PROCESS into an account of temporal phenomena which takes STATE vs EVENT as the ruling dichotomy?

Approach of this paper, in a nutshell:

- ▶ Processes are a radically different *kind* of entity from states and events.
- ▶ This means that any attempt to bring the three categories together in a simple subsumption hierarchy is doomed to failure.
- ▶ Processes are abstract entities which may be *realised* as concrete entities which are actually occurring states and events.

Types and Tokens

The type/token distinction seems to lend itself readily to events. But what about states and processes?

What is a token of *walking*?

At 10.40 a.m. on Sunday 1st January 2012, I was walking in Exeter.

If there is a walking token here, what is its temporal extent?

What is a token of walking?

At 10.40 a.m. on Sunday 1st January 2012, I was walking in Exeter.

- Option 1: My walking at 10.40 a.m. constitutes a single walking token, distinct from an indefinite number of walking tokens at other individual times.

- Option 2: The walking token spreads back in time to when I started walking (say at 10.35 when I left my house) and forward to when I stopped (at 10.45 when I arrived at the station).

Option 1 picks out something very like a **state**: the *state of my walking at 10.40am*.

Option 2 picks out something very like an **event**: *My walk to the station*, which lasted from 10.35 to 10.45.

What is a token of walking?

We seem to have

- ▶ An event token — my complete walk to the station — which occupies a certain 10-minute stretch of time.
- ▶ An indefinite number of state takens — all the momentary states of walking — that in aggregate give rise to the complete walk.

What has happened to the process?

"*Processes are repeatable behaviours whose occurrences cause continuants to undergo change.*" (Özgövde and Grüninger)

Roughly speaking, walking is a "repeatable behaviour" of which certain actual state and event tokens we find in the world are "occurrences".

Continuables and Repeatables

We distinguish:

- **Repeatable** behaviours whose occurrences are actual events, e.g., *walking to the station*, *walking for five minutes*, *walking 500 metres*.

- **Continuable** behaviours which can be realised over arbitrarily short time intervals and can meaningfully be ascribed to arbitrary moments within any interval over which it is realised (state-like realisation), e.g., *walking*.

Simple Generic Continuables

A simple generic continuable is a homogeneous, open-ended behaviour which may be "enacted" by an "agent" or set of "agents" over a period of time.

Simple generic continuables are typically denoted by simple verbs such as *run*, *sing*, *eat*, *whistle*.

They are "abstract" in the sense that they do not in themselves have any material reality; rather, they are patterns which may be *realised* at different times and places.

Continuables with "Non-delimiting Objects"

A simple generic continuable can be made more specific by attaching to it a **non-delimiting qualification**, which qualifies the continuable in an open-ended way (i.e., without importing telicity).

▶ **Examples:**
 sing songs. *sing Schubert*, *eat apple*, *eat apples*, *run northwards*

Simple Specific Continuables

A **simple specific continuable** is derived from a simple generic continuable by restricting it to a particular agent or set of agents.

- **Examples:**
  John runs, *Mary sings*, *Mary sings songs*, *Mary sings Schubert*, *Bill eats*, *Bill eats apples*, *The kettle whistles*

These are still abstract (not located in space and time).

Compound Continuable

Simultaneous composition: Two continuables may be combined to form a continuable whose realisations are the simultaneous realisations of the two constituent continuables. General form: "*X* while *Y*ing".

The constituents may be either generic or specific.

- **Homogeneous composition:**
    - Both constituents generic: *read while eating*, *read poetry while eating chocolate*
    - Both constituents specific: *John reads while Mary eats*, *John reads poetry while Mary eats chocolate*

- **Heterogeneous composition:**
    - *X* constituent generic, *Y* specific: *read while Mary eats*, *read poetry while Mary eats chocolate*
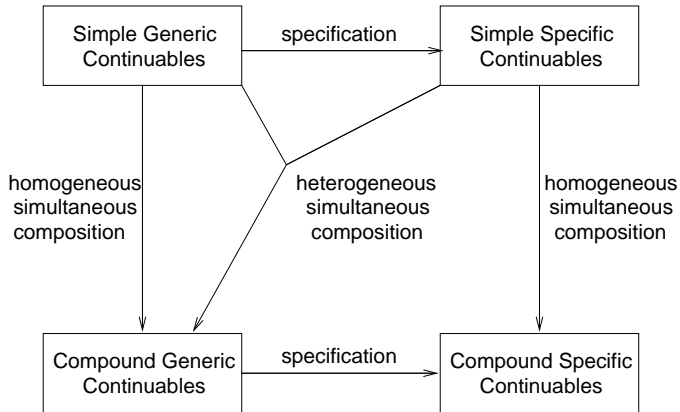
Repeatables

If we attach a **delimiting qualification** to a continuable, introducing the idea of *completion*, the result is no longer a continuable: once something has been completed, it cannot be continued! But it can (in principle) be repeated, so we call these **repeatables**.[1]

Examples:

- Simple generic repeatables: *run to the station*, *run a mile*, *sing for an hour*, *sing "Happy Birthday"*, *eat an apple*
- Simple specific repeatables: *John runs a mile*, *Mary sings for an hour*, *Mary sings "Happy Birthday"*, *Bill eats an apple*.

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[1]Alternative terminology I have considered using: **completables**.

Composition of Repeatables

Repeatables admit a wider range of modes of composition than continuables.

We use the relations of the **Interval Algebra** (see next slide).

Interval Composition: For each Interval Algebra relation R, repeatables t_1 and t_2 can be composed to give a repeatable $t_1 R t_2$, each of whose occurrences consists of an occurrence of t_1 related by R to an occurrence of t_2.

Example: *John bakes a cake{=,s,si}Mary writes an essay*

This means that John starts baking when Mary starts writing, but does not specify who finishes first.

The Interval Algebra

Allen's **Interval Calculus** consists of the 13 qualitatively different ways in which two intervals can be temporally related.
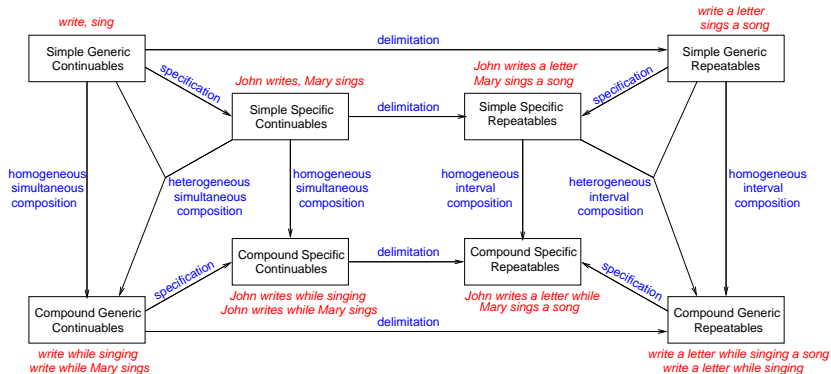

A is before B	A meets B	A overlaps B	A equals B	A starts B	A is during B	A finishes B
<	m	o	=	s	d	f
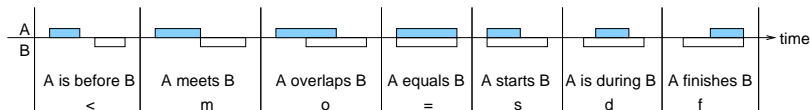
$(<,$ m,o, s, d, f have inverses $>$, mi, oi, si, di, fi)

The **Interval Algebra** contains all $2^{13} = 8192$ possible *sets* of Interval Calculus relations, interpreted as *disjunctions*.

▶ E.g., $x\{=,s,si\}y$ means x equals, starts, or is started by y.

Continuables and Repeatables

Realisations

Continuables and repeatables are abstract types of activity which can be instantiated as concrete realisations which are fully determinate with respect to their spatio-temporal and other characteristics.

Continuables and repeatables provide a repertoire of descriptive resources that can be used to specify the form of actual states and events.

- ▶ States provide an **experiential** window on the world, describing it from the point of view of a participant in it, as a succession of *snapshots* (cf. the "SNAP" ontology in BFO)
- ▶ Events provide a **historical** window on the world, describing it from a synoptic viewpoint *spanning* whole periods (cf. the "SPAN" ontology in BFO)

The realisation operation

"Mary is singing" — the current state of the world includes a realisation of the simple specific continuable *Mary sings*.

"Mary sang *Happy Birthday* yesterday" — that part of the history of the world designated "yesterday" includes a realisation of the simple specific repeatable *Mary sings "Happy Birthday"*.
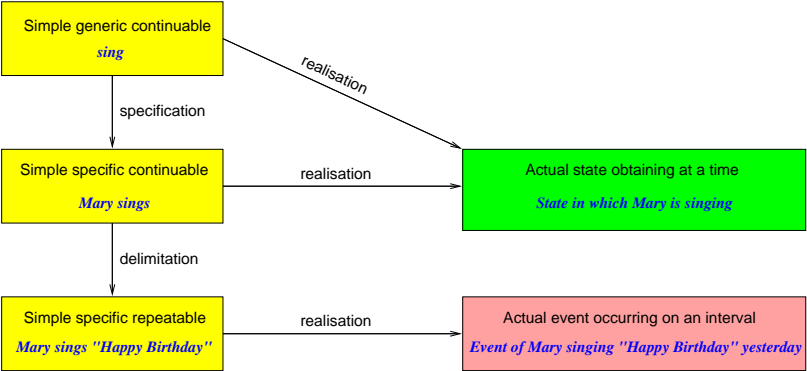
The "null delimiter"

Can a continuable be realised as an event rather than a state?

"Mary sang twice yesterday"

Here "twice" suggests we are dealing with a repeatable; but *sing* is a continuable.

Solution: We introduce a **null delimiter** which converts the continuable "sing" to a repeatable *sing (for a while)* whose realisations are *episodes* of singing.

An episode of Mary's singing consists in Mary starting to sing, singing for a while, and then stopping singing.

The null delimiter is denoted *Po*.
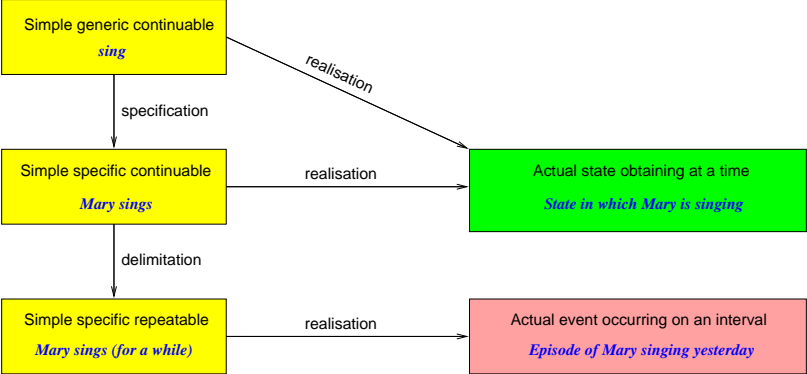
Progressivisation

Can a repeatable be realised as a state rather than an event?

"John is baking a cake"

This denotes a state; but it is a state that is described in terms of the repeatable *John bakes a cake*.

A realisation of *John bakes a cake* is *complete* — i.e., there is a cake at the end of it. But "John is baking a cake" does not imply that there will be a cake.

We introduce a **progressive operator** which maps a repeatable to a continuable which is realised as a state which holds by virtue of the repeatable being "in progress".
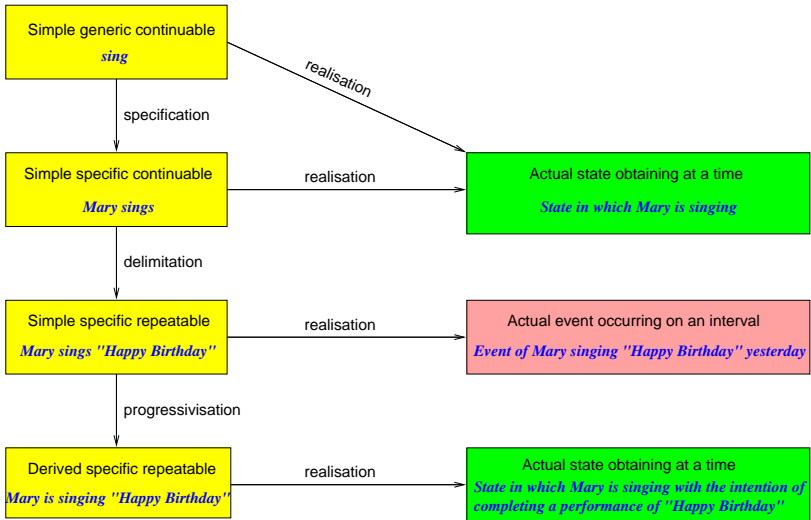
Progressivisation (continued)

What does it mean for a repeatable to be "in progress"?

It means that some state holds which is *progressing* or *directed* towards the completion of the repeatable.

There are three main ways in which such directedness can arise:

- ▶ Intention
- ▶ Causation
- ▶ Factuality

We use the operator *Prog* to map a repeatable to its progressivisation.

Processes revisited

Where are the processes in all this?

"Process" is a generic term that applies to all kinds of continuables and repeatables.

It does not refer directly to concrete continuants and occurrents in the world, which should be regarded as realisations of processes.

Processes revisited (continued)

Simple generic continuables correspond to the notion of process as "the topic-neutral counterpart of activity" (Mourelatos, 1981). They are realised as the *stative perdurants* (encompassing both states and processes) of DOLCE.

At the other extreme, compound specific repeatables correspond to completable routines comprising a structured sequence of actions or events, e.g., *make a pot of tea*, *check in for a flight*, *assemble a model from a kit*, *apply for a new passport*. They are realised as accomplishments (eventive perdurants) of DOLCE.

Processes revisited (continued)

The category of process is neither subordinate to nor superordinate to the categories of state and event.

Nor is it on the same footing as them with some immediate common superordinate category.

Process belong in the realm of abstract entities (patterns of behaviour), quite separate from the realm of spatio-temporal entities which includes both states and events.

What next?

- ▶ Granularity — what at one level of granularity appears as a realisation of a homogeneous process may appear to be structured (and hence compound) at fine granularity (e.g., *hammering*).

- ▶ A typical structured process is realised as the periodic repetition of some sequence of events (e.g., *walking*).

- ▶ We need operators to allow the construction of such "higher-order" continuables from lower-level repeatables. (E.g., a *frequentative* operator.)

THANK YOU

Any questions?