Analytic Metaphysics

Lecture 4
Barry Smith
February 23, 2016
What is going on here?

ah sh uqwuj a?

ywye has uw has!
Reality is revealed, incrementally, by experimentally-based science

(And what applies to science applies also to many non-scientific domains where large cross-community communication and testing for consistency is needed, e.g. international commerce)
Three Levels to Keep Straight

• Level 1: the entities in reality, both instances and universals

• Level 2: cognitive representations of this reality, e.g. on the part of scientists ...

• Level 3: publicly accessible concretizations of these cognitive representations in textual and graphical artifacts
What is going on here?

ah sh uqwju ja?

ywye has uw has!
Basic axioms of Ontological Realism

• There is an external reality which is ‘objectively’ the way it is, and
• That reality is accessible to us;
  –   \( \rightarrow \) L1
• We build in our brains cognitive representations of reality;
  –   \( \rightarrow \) L2
• We communicate with others about what is there, and what we believe there is there.
  –   \( \rightarrow \) L3

Science

*starts* with: Level 2 = the cognitive representations of researchers in the relevant domain

proceeds through experiments

*results* in: Level 3 representational artifacts (science textbooks)
The methodology of ontological realism

• Find out what the world is like (primarily) by doing science

• Create ontologies adequate to this world, not to some simplified model in your laptop

• Build representations of *entities in the world*, not of *the concepts in your colleagues’ heads* or of *the data in their databases*

http://iospress.metapress.com/content/1551884412214u67/fulltext.pdf
Scientific ontologies are comparable to scientific theories = representations of what is general in reality

Scientific ontologies must be evidence-based, which means: based in the observation of instances in the laboratory
Scientific ontologies have a special feature

Every term in the ontology must be such that the developers of the ontology believe it to refer to some general entity in reality (some type or universal – something generalizable) on the basis of the best current evidence.

Entities in reality include also information artifacts, scientific experiments, organizations, national borders, …
The central distinction

*universal vs. instance*

*human being vs. Arnold Schwarzenegger*

*science text vs. diary*

*catalog vs. inventory*
Ontologies are representations of universals in reality

*aka* kinds, types, categories, species, genera, ...
A  515287  DC3300 Dust Collector Fan
B  521683  Gilmer Belt
C  521682  Motor Drive Belt
A 515287  DC3300 Dust Collector Fan
B 521683  Gilmer Belt
C 521682  Motor Drive Belt

instances
universals vs. their extensions

The extension of the universal $A$ is the class of $A$’s instances

universal

\{a, b, c,...\}

collection of particulars
universals vs. their extensions

The extension at $t$ of an object universal $A$ is the class of $A$’s instances = the aggregate of $A$’s at $t$

- object universal $A$

$\{a, b, c, \ldots\}$

aggregate of objects $x$ for which $x$ instance_of $A$ at $t$
For scientific ontologies it is *generalizations* (universals: *patient*, *headache*, *MRI image*) that are important.

For databases it is (normally) instances that are important

= particulars in reality:

- patient #0000000001
- headache #0000000004
- MRI image #233000014, etc.
 universals

 mammal

 animal

 organism

 object

 siamese

 cat

 instances

 frog
Each photographic image is a representation of one or more instances
We can’t take photographs of universals

But we can create cartoons and diagrams
How do we know which general terms designate universals?

Roughly: terms used in a plurality of sciences to designate entities about which we have a plurality of different kinds of testable propositions / laws

(compare: cell, electron, membrane ...)

Not all general terms correspond to universals

<table>
<thead>
<tr>
<th>Clear cases</th>
<th>Problem cases</th>
<th>Clear non-cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>cell</td>
<td></td>
<td>brother of Elvis fan</td>
</tr>
<tr>
<td>membrane</td>
<td></td>
<td>chemical whose name begins with ‘B’</td>
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<tr>
<td>retina</td>
<td></td>
<td>thing owned by the emperor</td>
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<tr>
<td>lung</td>
<td>dark matter</td>
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<tr>
<td>planet</td>
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</table>
Scientists make mistakes

There is no algorithm for telling us whether a given term designates a universal, just as there is no algorithm for telling us whether a given statement is true.

In both cases we have to rely on the same thing: the best current scientific evidence.
The Foundational Model of Anatomy (FMA) Ontology

An ontology of canonical human anatomy, representing the entities and relations making up the human body in a form that is understandable to humans and also navigable by machines.

Canonical ≠ statistically normal:
Canonically, all humans have 32 teeth

http://sig.biostr.washington.edu/projects/fm/AboutFM.html
BFO: A First Look

Continuant

Independent Continuant  Dependent Continuant

Occurrent (Process, Event)

universals

instances
Midas-Touch Epistemology
(a dominant view in many circles)

Reality in itself exists behind a veil

We can never see or understand reality as it is in itself

The best we can do is *tell conceptual stories*

The alternative

**Ontological realism:**

reality exists behind a *transparent* grid

= a veridical partition

Barry Smith, “Beyond Concepts”,
http://ontology.buffalo.edu/bfo/Beyond_Concepts.pdf
Many veridical partitions

Common sense involves many verdical partitions

otherwise we would all be dead

The common sense partitions of folk physics, folk psychology, folk biology, are to a large degree transparent to reality. It is such common sense partitions that are involved, for instance, when someone takes your temperature in the hospital.
The fundamental thesis of ontological realism

many of our commonsensical and many of our scientific partitions are transparent to reality
BFO deals with everything that is real

This includes ideas, thoughts, beliefs, emotions

See

Mental Functioning Ontology
Emotion Ontology

http://code.google.com/p/mental-functioning-ontology/

*mental functioning* is a subtype of BFO:*process*
How BFO is constructed and maintained

How does BFO deal with information artifacts (documents, emails, websites, databases, ontologies, photographs …)?

See

Information Artifact Ontology (IAO)

http://code.google.com/p/information-artifact-ontology/
For BFO, universals are admitted only if they have instances in reality

Fictions (‘unicorn’) do not have instances
‘Average salary’ does not have instances

Some references to instances do not refer to universals:

*person cleansed in the waters of the Ganges*
*person who flew on a plane with Bill Clinton*
universals vs. their extensions

The extension at $t$ of an object universal $A$ is the class of $A$’s instances = the aggregate of $A$’s at $t$

- object universal $A$
- \{a, b, c, ...\}
- aggregate of objects $x$ for which $x \text{ instance_of } A$ at $t$
Universals vs. their extensions

Some classes are not extensions of universals

- Object universal A

{a, b, c,...} defined classes
<table>
<thead>
<tr>
<th>...</th>
<th>up</th>
<th>down</th>
<th>charm</th>
<th>strange</th>
<th>...</th>
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<tbody>
<tr>
<td>...</td>
<td>19</td>
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<td>K</td>
<td>Ca</td>
<td>Sc</td>
<td>Tv</td>
<td></td>
</tr>
<tr>
<td></td>
<td>John</td>
<td>Paul</td>
<td>George</td>
<td>Ringo</td>
<td></td>
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When we measure temperatures we impose a quantitative partition.

John’s temperature endures through time.
| ... | 37.1°C temperature | 37.2°C temperature | 37.3°C temperature | 37.4°C temperature | ... |
Temperature qualities form a continuum

- Embryo
- Fetus
- Neonate
- Infant
- Child
- Adult

in nature, no sharp boundaries here

Temperature qualities form a continuum.
Tracking a disease through time

Coronary heart disease (CHD)

- CHD in phase of early lesions and small fibrous plaques
  - instantiates at \( t_1 \)
- CHD in phase of asymptomatic ('silent') infarction
  - instantiates at \( t_2 \)
- CHD in phase of surface disruption of plaque
  - instantiates at \( t_3 \)
- Unstable angina
  - instantiates at \( t_4 \)
- Stable angina
  - instantiates at \( t_5 \)

In nature, no sharp boundaries here

John’s coronary heart disease
Tracking an organism through time

in nature, no sharp boundaries here

human

embryo

fetus

neonate

infant

child

adult

instantiate at $t_1$
instantiate at $t_2$
instantiate at $t_3$
instantiate at $t_4$
instantiate at $t_5$
instantiate at $t_6$

John
tracking an organ through time

viewing reality through a partition in which portions of matter form a single unit evolving over time
states of heart development

viewing reality through a partition in which portions of matter form a single unit evolving over time
tracking a tumor through time

viewing reality through a partition in which portions of matter form a single unit evolving over time
melanoma growth stages

viewing reality through a partition in which portions of matter form a single unit evolving over time
tumor development

Day
0 65 167 208 250

Volume cm³
1.1 28.3 63.1 64.2 88
The Time Problem

The tumor developed in John’s lung over 25 years
The Time Problem

_____ developed in ______ over 25 years

process
The tumor developed in the lung over 25 years.
The Problem

The tumor developed in the lung over 25 years.

what is it that participates in this process of tumor development?

parthood here not determinate
The Problem

The tumor developed in the lung over 25 years.

Gluing these two types of entities together yields ontological problems.
The Problem

The tumor developed in the lung over 25 years, leading some to deny that objects (continuants) exist = Process metaphysics, Four-dimensionalism, ...
Continuants vs occurrents

In preparing an inventory of reality, we keep track of these two different kinds of entities in two different ways.
realization specifically\_depends\_on realizable

- Continuant
  - Independent Continuant bearer
  - Specifically Dependent Continuant disposition
  - Process of realization

- Occurrent
Realizable dependent continuants

Role: nurse role, pathogen role, food role
Disposition: fragility, virulence, susceptibility, genetic disposition to disease X
Function: to pump (of the heart), to unlock (of the key)
Specific Dependence

on the instance level

a \textbf{depends\_on} b =\text{def.} a \text{ is necessarily such that if } b \text{ ceases to exist than } a \text{ ceases to exist}

on the type level

A \textbf{specifically\_depends\_on} B =\text{def.} for every instance a of A, there is some instance b of B such that a \textbf{depends\_on} b.
specifically_depends_on

Continuant

Independent Continuant
thing

Dependent Continuant
quality

Occurrent
process, event

temperature depends on bearer
Specifically dependent continuants

- the *quality* of whiteness of this cheese
- your *role* as lecturer
- the *disposition* of this patient to experience diarrhea
An example of a quality

• The particular redness of the left eye of a single individual fly
  – An instance of a quality universal

• The color ‘red’
  – A quality universal

• Note: the eye does not instantiate ‘red’

• PATO represents quality universals: color, temperature, texture, shape …
the particular case of redness (of a particular fly eye)

depends_on

an instance of an eye (in a particular fly)

the universal red

instantiates

the universal eye

instantiates
the particular case of redness (of a particular fly eye) instantiates an instance of an eye (in a particular fly)

depends on

is_a

is_a

color

anatomical structure

depends on

instantiates

red

eye

the particular case of redness (of a particular fly eye)
an instance of an eye (in a particular fly)
BFO partitions reality

all terms included in the ontology are intended to designate universals in reality, in conformity with the basic principle of science-based ontology

but this means that science-based ontologies are on the one hand windows on the universals in reality, but on the other hand windows on the instances in reality
3 kinds of binary relations

Between universals (types):

- *human is_a mammal*
- *cell nucleus part_of cell*

Between an instance and a universal:

- *this human instance_of the universal human*
- *this human allergic_to the universal penicillin*

Between instances:

- *Mary’s heart part_of Mary*
- *Mary’s aorta connected_to Mary’s heart*
OBO Relation Ontology (2005)

Three kinds of relations

<universal, universal>: is_a, part_of, ...

<instance, universal>: this explosion
   instance_of the universal explosion

<instance, instance>: Mary’s heart
   part_of Mary
OBO Relation Ontology
A constrained suite of type-type relations

| Foundational | is_a  
|              | part_of |
| Spatial      | located_in  
|              | contained_in  
|              | adjacent_to |
| Temporal     | transformation_of  
|              | derives_from  
|              | preceded_by |
| Participation| has_participant  
|              | has_agent |

“Relations in Biomedical Ontologies”,
Genome Biology, April 2005
Definitions of type-level relations presuppose underlying instance-level relations

A is_a B =def. all instances of A are instances of B
presupposes instance_of

A part_of B =def. every instance of A are instance-level-parts-of some instance of B
presupposes instance-level-part-of
Disposition (Internally-Grounded Realizable Entity)

disposition =def.

a realizable entity which if it ceases to exist, then its bearer is physically changed, and

whose realization occurs when this bearer is in some special physical circumstances, in virtue of the bearer’s physical make-up
Function (A Good, Designed Disposition)

function = def.

a capability that exists in virtue of the bearer’s physical make-up,
and this physical make-up is something the bearer possesses because it came into being, either through evolution (in the case of natural biological entities) or through intentional design (in the case of artifacts), in order to realize processes of a certain kind.
Functions are associated with certain characteristic *process shapes*

Screwdriver: rotates and simultaneously moves forward simultaneously transferring torque from hand and arm to screw

Heart: performs a contracting movement inwards and an expanding movement outwards
Functions and Prototypes

In its functioning, a heart creates a four-dimensional process shape. Good hearts create other process shapes than sick hearts do.
Specifically Dependent Continuants

if any bearer ceases to exist, then the quality or function ceases to exist

the color of my skin

the function of my heart
Generically Dependent Continuants

if one bearer ceases to exist, then the entity can survive, because there are other bearers (copyability)

*the pdf file on my laptop*

*the DNA (sequence) in this chromosome*
Information objects

pdf file
poem
symphony
algorithm
symbol
sequence
molecular structure
Generically dependent continuants such as plans, laws …

are concretized in specifically dependent continuants
(the plan in your head, the protocol being realized by your research team, the law being implemented by this government agency)
Если должник перестал выплачивать ссуду, и кредитор требует чтобы вы, как поручитель или совместный заемщик, взяли на себя выплаты ссуды или угрожает подать на вас в суд, обратитесь за юридической консультацией.

В некоторых ограниченных ситуациях, поручитель может оспорить иск, даже если он подписал контракт. Вы должны незамедлительно обратиться за советом, если вы считаете, что работник учреждения, которое выдало ссуду, брокер или продавец, который организовал финансы, обманул или ввел вас в заблуждение. Вы также должны незамедлительно обратиться за юридической консультацией, если на момент подписания контракта:
Generically dependent continuants are concretized in specifically dependent continuants

*Beethoven’s 9th Symphony* is concretized in the pattern of ink marks which make up this score in my hand
Generically dependent continuants do not require specific media (paper, silicon, neuron …)
Information Entity (science)

protocol
database
theory
ontology
gene list
publication
result
...

Information Entity (labeling)

serial number
batch number
grant number
person number
name
address
email address
URL
...

Type or instance

Continuant

Independent Continuant
human being, protocol document

Dependent Continuant
pattern of ink marks

Occurrent (Process)

Applying the protocol

Side-Effect ...
Continuant

Independent Continuant

Dependent Continuant

Information Entity

Occurrent

Action of creating an information entity
What is a work of literature?

Is *War and Peace* a universal or an instance?

If *War and Peace* were a universal, and the copies of *War and Peace* in my library and in your library were instances of this universal, then there would be many *War(s) and Peaces*.

This does not seem right.

Hence *War and Peace* is an instance.
War and Peace is not a universal
of which its copies would be instances

• Rather, War and Peace is an instance of the type *novel*
• Its copies are instances of the type *book.*
• Information entities exist in a way which makes them dependent on provenance, and on processors, in a way in which universals are not
There are not two Declarations of Independence

- There are two copies of the US Declaration of Independence
- There cannot be subtypes of the US Declaration of Independence
- Hence the US Declaration of Independent is an instance and not a type.
Rule for universals

Their names are pluralizable

There can be *three people*
There cannot be *three Michelle Obamas*

*Person* is a universal; *Michelle* is an instance

Information entities = (roughly) entities which can exist in many perfect copies
add relation of concretization

GDC: plan specification
SDC: concretization of this plan specification in the patterns of ink in this printed document
SDC: concretization of this plan specification in your head (your plan)
Music

Beethoven’s 9th Symphony, a certain abstract pattern (generically dependent continuant), which we shall call the 9th Symphony

9th Symphony instance_of symphony

symphony is_a a musical work.

9th Symphony instance_of musical work

9th Symphony concretized_in specifically dependent continuant pattern of ink marks borne by this printed copy of the score
Symphony No. 9 in D Minor

 Allegro ma non troppo, un poco maestoso \( \text{\#} = 88 \)

Ludwig van Beethoven

Transcribed by Franz Liszt
Music

this score instance_of generically dependent continuant universal: plan specification

(it specifies how to create a performance)

this plan specification is concretized_in this network of subplans (complex realizable SDC) distributed across the minds of the conductor and members of this orchestra

this network of subplans realized_in this performance (process)

this performance is “copied” in what you hear (a process inside your head)
The mouth of a cave

Fiat boundary
Boundaries go together with sites
A cave (site)

Fiat boundary
Double Hole Structure

- **Retainer**
  (a boundary of some surrounding structure)

- **Medium**
  (filling the environing hole)

- **Tenant**
  (occupying the central hole)
Ambiguity of ‘Manhattan’

- Manhattan as material entity (a collection of bricks and rock and other solid matter)
- Manhattan as a complex site (the place where people actually live and move)
- Extended Manhattan = the sum of the above

analogously for cave, mouth, nostril, your car, your lab, your bed (getting into bed …)
The Environment Ontology

- independent continuant
  - material entity
    - system
      - environmental system
        - object
          - object aggregate
            - ocean
            - desert
            - gut
        - organism
          - population
          - community
      - ecosystem
          - biome
          - habitat
          - niche

re ‘ocean’ – compare ambiguity of ‘Manhattan’
Environment and System

System =def. A BFO:independent continuant which is composed of interacting material entities forming an integrated whole.
(System, e.g. the hydraulic system in your car, still exists even when switched off)

Environmental system =def. A system which includes a BFO:site as a component.’

Synonym: Environment. (When one speaks of an entity’s environment, what is meant is an environmental system that the entity is a member of.)
Ecosystem

Ecosystem =def. An environmental system that includes living entities as components.

Biome =def. An ecosystem which contains ecological communities adapted to the environmental conditions conserved over its site.

Habitat =def. An ecosystem which can support the persistence [= over several generations] of a given PCO: population.
Niche

**Fundamental niche** = def. An ecosystem which is that part of a habitat which *can* support the life of a given ecological species.

**Realised niche** = def. An ecosystem which is that part of a habitat which *does* support the life of a given ecological species.
Continuant boundaries go together with sites
sites are different from three-dimensional spatial regions?

A site, e.g. the hold of a ship, can move through space (and thus occupy successively different spatial regions)

Sites are in this respect, too, analogous to material entities.
focus on fiat boundaries

when we talk about e.g. 2-dimensional surfaces of material objects, then we are talking about fiat boundaries

= boundaries for which there is no assumption that they coincide with physical discontinuities.
Continuant boundaries go together with (0-, 1-, and 2-D) spatial regions.
as sites go together with 3-D spatial regions
and material entities go together with 3-D spatial regions
just as process boundaries go together with temporal instants.
so processes go together with temporal intervals