A formal definition of ontological categories

Pawel Garbacz

The John Paul II Catholic University of Lublin

2015-07-05
Problem

Given a body of knowledge and its set of categories, if \( C \) is a category, under what conditions is \( C \) an ontological category?

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When it comes to defining an ontology (be it philosophical or applied), relations are more fundamental than categories.
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Available accounts of ontological categories – [Westerhoff, 2005]:

1. Universalist
2. Substitutional
3. Identity-based
4. Modal
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1. universalist
2. substitutional
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Universalist accounts of ontological categories

[Norton, 1976]: An ontological category is any natural category that is directly subsumed by the universal category.

Another: [van Inwagen, 2012]

They stop at the very first level of "the tree of being", e.g., [Norton, 1976]

They do not set cut-off point at all, e.g., [van Inwagen, 2012]
Universalist accounts of ontological categories

- **formulation:**
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- **issues**
  - unable to define a non-arbitrary cut-off point:
    1. they stop at the very first level of “the tree of being”, e.g., [Norton, 1976]
    2. they do not set cut-off point at all, e.g., [van Inwagen, 2012]
  - *may* provide a flat list of categories, e.g., [Norton, 1976]
Substitutional accounts of ontological categories

congruent substitutability as an equivalence relation

types of substitutability

1 with respect to the type of congruence

grammar is preserved

meaningfulness is preserved

2 with respect to the type of structure being substituted

language, usually sentences

reality, usually states of affairs
Pawel is confused.
The President of Italy is confused.
Monday is confused.
Substitutional accounts of ontological categories

Lazily is confused.
congruent substitutability as an equivalence relation
Substitutional accounts of ontological categories

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Substitutional accounts of ontological categories (2)

[Sommers, 1959]: an ontological category is an equivalence class of the relation of semantically congruent linguistic substitutability

[Westerhoff, 2005]: an ontological category is an equivalence class of the relation of congruent ontic substitutability

Language-dependent tend to generate too specific or ontologically odd categories:

1. e.g., the category of buildings (consider \". . . has a green back door\"

Provide a flat list of categories with significant vagueness.
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- **issues**
  - language dependent
  - tend to generate too specific or ontologically odd categories:
    - e.g., the category of buildings (consider “... has a green back door”)
  - provide a flat list of categories
  - significant vagueness
Identity-based accounts of ontological categories

Dummett, 1973, p. 73-76, defines ontological categories as the most general categories whose instances have the same criterion of identity, e.g., man, woman, tailor, person.

Issues provide flat lists of ontological categories vulnerable to the various controversies pertinent to the notion of identity criteria.
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issues

- provide flat lists of ontological categories
- vulnerable to the various controversies pertinent to the notion of identity criteria
- provide a flat list of categories
Modal accounts of ontological categories

formulation:

rigid properties constitute ontological categories

issues tend to generate too specific categories:

e.g., mammals, vertebrates or chordates seem to be rigid, but they are not ontological
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Modal accounts of ontological categories

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Formal requirements for any future theory of ontological categories

Some categories are not ontological. A set of categories may be ordered by the subsumption relation and the resulting hierarchy may have more than one level.

1. If a category is not ontological, then all of its subcategories (if any) are not ontological.
2. If a category is ontological, then all of its supercategories (if any) are ontological.
Formal requirements for any future theory of ontological categories

- some categories are not ontological
Formal requirements for any future theory of ontological categories

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Formal requirements for any future theory of ontological categories

- some categories are not ontological
- a set of categories may be ordered by the subsumption relation and the resulting hierarchy may have more than one level
- there is a cut-off point:
  1. if a category is not ontological, then all of its subcategories (if any) are not ontological
  2. if a category is ontological, then all of its supercategories (if any) are ontological
Ontological relations – A way out?

We can sieve out ontological categories by means of ontological relations. Ontological relations cut ontological categories at their (i.e., categories') joints:

1. No ontological category is torn apart by an ontological relation.
2. Ontological categories are maximally general.
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ontological relations cut ontological categories at their (i.e., categories’) joints:

1. no ontological category is torn apart by an ontological relation
2. ontological categories are maximally general
Ontological categories in existential ontology – example

Ontological pluralism: things exist in different ways

\[ x \text{ belongs to the same ontological category as } y \iff x \text{ exists in the same way as } y. \]  

(1)

\[ x \text{ exists in the same way as } y \iff x \text{ depends on the same ontological categories as } y. \]  

(2)

two things belong to the same ontological category iff they depend on the things from the same ontological categories
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two things belong to the same ontological category iff they depend on the things from the same ontological categories
Dependence-based account of ontological categories – assumptions

Each entity from the domain, say some $x$, either falls under some category $C (\text{Inst}(C, x))$ or not ($\neg \text{Inst}(C, x)$).
 Dependence-based account of ontological categories – assumptions

- set $\mathcal{C}$ of categories: $C_1, C_2, \ldots$
- each entity from the domain, say some $x$, either falls under some category $C$ ($\text{Inst}(C, x)$) or not ($\neg \text{Inst}(C, x)$)
- “dep” to refer to the relation of existential dependence between the entities from its domain
Dependence-based account of ontological categories – formal definitions

\[ C \equiv \{ x : \text{Inst}(C, x) \}. \] (3)

\[ \text{dep}(x, C) \equiv \exists y \left[ \text{dep}(x, y) \land \text{Inst}(C, y) \right]. \] (4)

\[ x = \text{dep}y \equiv \forall C \left[ \text{dep}(x, C) \equiv \text{dep}(y, C) \right]. \] (5)
Dependence-based account of ontological categories – formal definitions

\[ \text{ext}(C) \triangleq \{ x : \text{Inst}(C, x) \}. \] (3)
Dependence-based account of ontological categories – formal definitions

\[ \text{ext}(C) \triangleq \{ x : \text{Inst}(C, x) \}. \quad (3) \]

\[ \text{deP}(x, C) \triangleq \exists y [\text{dep}(x, y) \land \text{Inst}(C, y)]. \quad (4) \]
Dependence-based account of ontological categories – formal definitions

\[
\text{ext}(C) \triangleq \{x : \text{Inst}(C, x)\}. \tag{3}
\]

\[
\text{deP}(x, C) \triangleq \exists y [\text{dep}(x, y) \land \text{Inst}(C, y)]. \tag{4}
\]

\[
x =_{\text{dep}} y \triangleq \forall C [\text{deP}(x, C) \equiv \text{deP}(y, C)]. \tag{5}
\]
Dependence-based account of ontological categories – main claim

∀C∃x_{ext}(C) = [x]_{dep}.

(6)

∀x∃C_{Inst}(C, x).

(7)

A finite C of categories is a set of ontological categories if it satisfies conditions 6 and 7.
Dependence-based account of ontological categories – main claim

\[ \forall C \exists x \text{ ext}(C) = [x]_{\text{dep}}. \]  (6)
Dependence-based account of ontological categories – main claim

∀C∃x \text{ext}(C) = [x]_{\text{dep}}. \quad (6)

∀x∃C \text{Inst}(C, x). \quad (7)
Dependence-based account of ontological categories – main claim

∀C∃x ext(C) = [x]_{dep}.

∀x∃C Inst(C, x).

A finite Ω of categories is a set of ontological categories if it satisfies conditions 6 and 7.
Dependence-based account of ontological categories – example

Ent: universal category

Obj: category of objects

Per: category of perdurants

End: category of endurants

Pro: categories of properties

Soa: category of states of affairs
Dependence-based account of ontological categories – example

1. Ent: universal category
2. Obj: category of objects
3. Per: category of perdurants
4. End: category of endurants
5. Pro: categories of properties
6. Soa: category of states of affairs
7. dep.
Dependence-based account of ontological categories – example (2)

\[ \forall x \text{Ent}(x) \] (8)

\[ \forall x [\text{Ent}(x) \equiv \text{Obj}(s) \lor \text{Pro}(x) \lor \text{Soa}(x)] \] (9)

\[ \forall x [\text{Obj}(x) \equiv \text{End}(x) \lor \text{Per}(x)] \] (10)

\[ \forall x [\text{Obj}(x) \rightarrow \neg \exists y \text{dep}(x, y)] \] (11)

\[ \forall x [\text{Pro}(x) \rightarrow \exists y (\text{Obj}(y) \land \text{dep}(x, y)) \] (12)

\[ \forall x, y [\text{Pro}(x) \land \text{dep}(x, y) \rightarrow \text{Obj}(y)] \] (13)

\[ \forall x [\text{Soa}(x) \rightarrow \exists y, z [(\text{Obj}(y) \land \text{dep}(x, y)) \land (\text{Pro}(z) \land \text{dep}(x, z))] \] (14)

\[ \forall x, y [\text{Soa}(x) \land \text{dep}(x, y) \rightarrow [(\text{Obj}(y) \lor \text{Pro}(y))] \] (15)
Dependence-based account of ontological categories – example (2)

\[\forall x \text{Ent}(x).\] (8)

\[\forall x [\text{Ent}(x) \equiv \text{Obj}(s) \lor \text{Pro}(x) \lor \text{Soa}(x)]\] (9)

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\[\forall x [\text{Obj}(x) \rightarrow \neg \exists y \text{dep}(x, y)]\] (11)

\[\forall x [\text{Pro}(x) \rightarrow \exists y (\text{Obj}(y) \land \text{dep}(x, y))]\] (12)

\[\forall x, y [\text{Pro}(x) \land \text{dep}(x, y) \rightarrow \text{Obj}(y)]\] (13)

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\[\forall x, y [\text{Soa}(x) \land \text{dep}(x, y) \rightarrow [(\text{Obj}(y) \lor \text{Pro}(y))]\] (15)
Dependence-based account of ontological categories – example (3)
Dependence-based account of ontological categories – example (3)

1. Ent, Per, End, are not ontological
2. Obj, Pro, Soa are ontological
Relational account of ontological categories – assumptions
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- set $\mathcal{C}$ of categories: $C_1, C_2, \ldots$
- $\text{Inst}(C, x)$
- finite set of binary ontological relations: $r_1, r_2, \ldots, r_n$
Relational account of ontological categories – formal definitions
Relational account of ontological categories – formal definitions

\[ \text{dom}(r, 1, x, C) \triangleq \exists y [r(x, y) \land \text{Inst}(C, y)] \] (16)
Relational account of ontological categories – formal definitions

\[ \text{dom}(r, 1, x, C) \triangleq \exists y [r(x, y) \wedge \text{Inst}(C, y)] \] (16)

\[ \text{dom}(r, 2, x, C) \triangleq \exists y [r(y, x) \wedge \text{Inst}(C, y)] \] (17)
Relational account of ontological categories – formal definitions

\[
\text{dom}(r, 1, x, C) \triangleq \exists y [r(x, y) \land \text{Inst}(C, y)] \quad (16)
\]

\[
\text{dom}(r, 2, x, C) \triangleq \exists y [r(y, x) \land \text{Inst}(C, y)] \quad (17)
\]

\[
x = \langle r, m \rangle y \triangleq \forall C [\text{dom}(r, m, x, C) \equiv \text{dom}(r, m, y, C)] \quad (18)
\]
Relational account of ontological categories – formal definitions

\[ \text{dom}(r, 1, x, C) \triangleq \exists y [r(x, y) \land \text{Inst}(C, y)] \]  
\[ \text{dom}(r, 2, x, C) \triangleq \exists y [r(y, x) \land \text{Inst}(C, y)] \]  
\[ x =_{<r,m>} y \triangleq \forall C [\text{dom}(r, m, x, C) \equiv \text{dom}(r, m, y, C)] \]  
\[ x =_r y \triangleq \forall m \, x =_{<r,m>} y \]
Relational account of ontological categories – main claim

∀r∀x∃Cext(C) = [x]r (20)

∀C∃r₁, r₂, . . . , rₖ∃xext(C) = k∏ᵢ=1[x]rᵢ (21)

A finite, non-empty set C of categories is a set of ontological categories (with respect to a set of ontological relations: r₁, r₂, . . . , rₙ) if both sets satisfy condition 20 and one or more conditions that fall under schema 21.
∀r∀x∃C ext(C) = [x]_r  

(20)
∀r∀x∃C \text{ ext}(C) = [x]_r \quad (20)

∀C∃r_1, r_2, \ldots, r_k∃x \text{ ext}(C) = \prod_{i=1}^k [x]_{r_i} \quad (21)
∀r∀x∃C \text{ ext}(C) = [x]_r \quad (20)

∀C∃r_1, r_2, \ldots, r_k ∃x \text{ ext}(C) = \prod_{i=1}^{k} [x]_{r_i} \quad (21)

A finite, non-empty set \mathcal{C} of categories is a set of ontological categories (with respect to a set of ontological relations: r_1, r_2, \ldots, r_n) if both sets satisfy condition 20 and one or more conditions that fall under schema 21.
Possible accounts of ontological relations

- [Simons, 2012]'s internal relations
- [Guarino, 2009]'s internal relations
- [Smith and Grenon, 2004]'s formal (ontological) relations

A formal definition of ontological categories
Possible accounts of ontological relations

- [Simons, 2012]’s internal relations
- [Guarino, 2009]’s internal relations
- [Smith and Grenon, 2004]’s formal (ontological) relations
A naive account of ontological relations – main idea

There are two types of generality involved.

A formal definition of ontological categories
A naive account of ontological relations – main idea

- A relation is ontological if there are no more general relations.
- There are two types of generality involved.
A naive account of ontological relations – two types of generality

1. \( r \) is more general\(_1\) than \( r' \) iff the latter is included in the former, i.e.,
\[
\forall x, y [r'(x, y) \rightarrow r(x, y)]. \tag{22}
\]

2. \( r \) is more general\(_2\) than \( r' \) iff the field of the latter is included in field of the former, i.e.,
\[
\forall x, y [r'(x, y) \rightarrow \exists z [r(x, z) \lor r(z, x) \lor r(y, z) \lor r(z, y)]]. \tag{23}
\]
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Simons, 2012’s internal relations

A relation R is internal to A and B iff it is essential to A and B jointly that ARB, so that necessarily, if A and B both exist, then ARB. [Simons, 2012, p. 138]

Issues:
1. Mathematical or logical relationships
2. Having the same spin (value), being a conjugated acid of, or about the phylogenetic relation
formulation:

A relation $R$ is internal to $A$ and $B$ iff it is essential to $A$ and $B$ jointly that $ARB$, so that necessarily, if $A$ and $B$ both exist, then $ARB$. [Simons, 2012, p. 138]
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A relation R is internal to A and B iff it is essential to A and B jointly that ARB, so that necessarily, if A and B both exist, then ARB. [Simons, 2012, p. 138]

issues:

1. mathematical or logical relationships
2. having the same spin (value), being a conjugated acid of, or about the phylogenetic relation
Guarino’s internal relations 

Simons’ internal relations

Within formal relations, I distinguish between the internal and the external ones, depending whether there is an existential dependence relationship between the relata. The basic kinds of internal relationships I have in mind (all formalized in DOLCE) are parthood, constitution, quality inherence, and participation, 

1. parthood (given mereological essentialism is false)
2. for historic rigid dependence: relation of parenthood is internal
3. for constant rigid dependence: causation is not internal
4. partial circularity

Issues:
formulation:

- formal relations \approx [Simons, 2012]'s internal relations
[Guarino, 2009]’s internal relations

formulation:

formal relations ≈ [Simons, 2012]’s internal relations

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issues:

1. parthood (given mereological essentialism is false)
2. for historic rigid dependence: relation of parenthood is internal
3. for constant rigid dependence: causation is not internal
4. partial circularity
[Smith and Grenon, 2004]’s formal (ontological) relations formulation:
Formal relations are those relations which hold (inter alia) between entities which are constituents of ontologies of different types and which are such that, if they hold between entities of given types, then necessarily all entities of those types enter mutatis mutandis into those relations. [Smith and Grenon, 2004, p. 295]
formulation:

*Formal relations are those relations which hold (sometimes inter alia) between entities which are constituents of ontologies of different types and which are such that, if they hold between entities of given types, then necessarily all entities of those types enter *mutatis mutandis* into those relations.* [Smith and Grenon, 2004, p. 295]
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*Formal relations are those relations which hold (sometimes inter alia) between entities which are constituents of ontologies of different types and which are such that, if they hold between entities of given types, then necessarily all entities of those types enter mutatis mutandis into those relations. [Smith and Grenon, 2004, p. 295]*

issues:

1. “the other way round” issue
For any class, if its boundary marks a real division among things, then either that class or its complement is a natural class – but not necessarily both. There are various ways in which there might be natural classes whose membership comprised “a really significant proportion of the things that there are.” (Let us call such a class “large.”) Say that a natural class is “high” if is not a proper subclass of any natural class.
For any class, if its boundary marks a real division among things, then either that class or its complement is a natural class – but not necessarily both.
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For any class, if its boundary marks a real division among things, then either that class or its complement is a natural class – but not necessarily both.

There are various ways in which there might be natural classes whose membership comprised “a really significant proportion of the things that there are.” (Let us call such a class “large.”)

Say that a natural class is “high” if is not a proper subclass of any natural class.
Let us say, first, that a natural class $x$ is a primary ontological category just in the case that - there are large natural classes - $x$ is a high class.
Let us say, first, that a natural class $x$ is a primary ontological category just in the case that - there are large natural classes - $x$ is a high class.
We say that $x$ is a natural subclass of $y$ if $x$ is a subclass of $y$ and $x$ is a natural class.

We say that $x$ is a large subclass of $y$ if $x$ is a subclass of $y$ and $x$ comprises a significant proportion of the members of $y$.

We say that $x$ is a high subclass of $y$ if $x$ is a natural proper subclass of $y$ and is a proper subclass of no natural proper subclass of $y$. 
We say that $x$ is a natural subclass of $y$ if $x$ is a subclass of $y$ and $x$ is a natural class.

We say that $x$ is a large subclass of $y$ if $x$ is a subclass of $y$ and $x$ comprises a significant proportion of the members of $y$.

We say that $x$ is a high subclass of $y$ if $x$ is a natural proper subclass of $y$ and is a proper subclass of no natural proper subclass of $y$. 

Then, a natural class $x$ is a secondary ontological category if there is a primary ontological category $y$ such that:

1. $y$ has large natural proper subclasses.
2. $x$ is a high subclass of $y$.

And, finally, an ontological category (simpliciter) is a class that, for some $n$, is an $n$-ary ontological category.
Then, a natural class $x$ is a secondary ontological category if there is a primary ontological category $y$ such that:

- $y$ has large natural proper subclasses;
- $x$ is a high subclass of $y$. 

And, finally, an ontological category (simpliciter) is a class that, for some $n$, is an $n$-ary ontological category.
Then, a natural class $x$ is a secondary ontological category if there is a primary ontological category $y$ such that
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And, finally, an ontological category (simpliciter) is a class that, for some $n$, is an $n$-ary ontological category.
For any class, if its boundary marks a real division among things, then either that class or its complement is a natural class—but not necessarily both.

[Norton, 1976, p. 107]