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# TOWARDS A SYSTEMATIC METHODOLOGY FOR FOUNDATIONAL ONTOLOGIES: PROPERTIES, RELATIONS, AND TRUTHMAKING

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# Overview

- Ontological commitments: the philosophical background.
- Ontological commitment: reification and truthmaking.
- Truthmakers of predicative sentences (properties and relations).

# Ontological commitment

A curious thing about the ontological problem is its simplicity.
It can be put in three Anglo-Saxon monosyllables:
*What is there?*
It can be answered, moreover, in a word – *Everything* – and everyone will accept this answer as true.

(Quine, *On what there is*, [Qui85])

# Quine

When Frege introduced quantification, he illuminated three subjects: logic, language, and ontology.

(Quine, *Events and Reification*, [Qui85])

To be is to be the value of a variable

(Quine, *On what there is*, [Qui48])

A theory is committed to those and only those entities to which the bound variables of the theory must be capable of referring in order that the affirmations made in the theory be true.

(Quine, *On what there is*, [Qui48])

# Quine's criterion:

- A *theory* is a set of sentences in an austere fragment of first-order logic such that:
- It contains: *n*-ary predicates, variables, existential and universal quantification, identity.
- I.e., no function symbols, no *individual constants*.
- In particular, individual constants do not directly manifest ontological commitment:

  *Socrates is tall* vs. *Pegasus does not exist*.
- Names that carry ontological commitment are retrieved by Russellian definite descriptions, to make the commitment explici:

$$\varphi(a) \text{ is replaced by } \exists x.(\varphi(x) \wedge \forall y.(\varphi(y) \rightarrow x = y)$$

- E.g. instead of using the name *Socrates*, use the predicate *is-Socrates*$(x)$

# Quine's existence

An existence predicate for Quine is defined by:

$$x \text{ exists iff } \exists y(x = y)$$

To be is to be the value of a variable

(Quine, *On what there is*, [Qui48])

# Examples

- Existential statements: $\exists x_1, \ldots, x_n.R(x_1, \ldots, x_n)$ entail ontological commitments.
- Predicating of individual constants some predicate $R$ would entail an ontological commitment.

$$\frac{R(a, b)}{\exists x.R(x, b)}$$

Provided we introduced the constants by means of definite descriptions.

# A CLASSICAL EXAMPLE: COMMITTING TO EVENTS

Davidson [Dav67][Dav01]

"John buttered the toast slowly with a knife" is represented in a predicative language by:

$$\exists e(\textbf{butter}(e, \textit{John}, \textit{the toast}) \,\&\, \textbf{slow}(e) \,\&\, \textbf{with a knife}(e))$$

where $e$ is a variable, *John* and *the toast* are constants, and **butter**/3, **slowly**/1, and **with a knife**/1 are predicates on events (modifying clauses).

By means of this formalisation, one can validate the inference:

*if* John buttered the toast slowly with a knife,
*then* John buttered the toast.

# Quine's problems

Quine's condition has been intensively discussed and challenged in analytical metaphysics (is it necessary for ontological commitment? is it sufficient?).

One line of arguments is that it *overgenerates*: That is, the mere existential quantifiers of first-order logic is not sufficient for bearing ontological commitments:

- For Quine, everything we may talk about, is in fact existing.
- Quine does not distinguish basic and derived entities (it is impartial wrt. reductions).

# Ontological commitment and truth-making

One way of refining Quine's view, is to introduce the notion of *truthmakers* (view approached in particular by Armstrong).

> "To postulate certain truthmakers for certain truths is to admit those truthmakers to one's ontology."

(Armstrong, *Truth and truthmakers* [Arm04])

# Truthmakers approach to ontological commitment

**Truthmaker criterion for ontological commitment**:

A theory $T$ is ontologically committed to a particular $a$ iff, if $T$ is true, then $a$ is a truthmaker for (some* sentences of ) $T$.

- That is, $a$ exists for $T$ iff $a$ is a truthmaker of some sentence of $T$ (when $T$ is true).
- Thus, by postulating the truthmakers of the sentences of $T$, we are listing the existence claims of $T$.

*: Debate on the nature of truthmakers of complex sentences (disjuncitons, negative statements, universal quantification).

[Bri16]

# Truth-making relation

Truth-making is a relation between a sentence $\varphi$ and some *thing* $t$. Three axioms [SSM14] (quite abstract constraints about truth-making relation):

- $(i)$ (Factive) If $t$ makes it true that $\varphi$, then $\varphi$.
- $(ii)^*$ (Existence) If $t$ exists, then $t$ makes it true that $\varphi$.
- $(iii)^{**}$ (Entailment) If $t$ makes it true that $\varphi$, and that $\varphi$ entails that $\psi$, then $t$ makes it true that $\psi$.

* : strong truth-making.
**: debated

- The property of the truth-making relation have been extensively debated and studied, e.g. [Mac18], [Res00] [Res96], [Rea00]

# Reification: making the truthmakers explicit

**Reification**. The process of representing predicates with constants and relations that link the constant to the arguments of the predicate.

E.g. the example of events, **butter**($e$, *John*, *toast*)

Reification is a way to make the truthmakers of a sentence explicit in the representation language.

Note that *reification* is a general mechanism, you may *reify* things that are not truthmakers.

Do reifications entail ontological commitment?

# Quine criterion, truthmakers, and reification

A framework for ontological commitment for formal ontologies:

- We keep Quine's view as a formal criterion for making the commtiment visible.
  I.e. commitment is visible in existentially quantified formulas.
- We reify the truthmakers of (some) sentences of $T$.
- We assume the truthmaking view, that is, ontological commitments are restricted to existentially quantified formulas about truthmakers.

A theory $T$ is committed to $a$ iff $a$ is the reference of an existentially bound variables which is a truthmaker of some sentence of $T$.

# Strong turthmaking

[Big88, Arm04]:

- The truthmakers debate is specifically about providing a meaningful grasping of the expression *in virtue of*.
- According to the mainstream theories, the truthmaker of a sentence is something the *existence* of which at a world *w* is necessary, sufficient, or both, for the truth of that sentence at *w*.

  *(T) x is a truthmaker of $\varphi$ at w iff for every w′, the existence of x at w′ entails the truth of $\varphi$ at w′.*

f *t* is a truthmaker of $\varphi$ at *w*, then *t* is a truthmaker of $\varphi$ in every *w* (*truthmaker essentialism*).

# Weak and strong truthmaking

- In 1999, Josh Parsons proposed an interesting non-orthodox approach to truthmaking [Par99, Par05] that denies the so-called *truthmaker essentialism*.
- Friedrike Moltmann speaks of strong and weak truthmaking in a different sense, to distinguish a truthmaker theory that admits truthmaker maximalism from one that does not [Mol13, p. 90]. [GG16], in contrast with *strong truthmaking*, which relies on principle (T).

# Weak truthmaking

Parsons describes weak truthmaking as follows, proposing two criteria that for him are equivalent[1]:

> *(i) for every true sentence, there is some thing such that the sentence cannot become false without a qualitative change, a non-Cambridge change, in that thing. That thing, whatever it is, is the sentence's truthmaker.*
>
> *(ii) [Or,] the truthmaker for a sentence is that thing that is intrinsically such that the sentence is true. [Par99, 328] (sentence numbers added)*

For a discussion of *i* and *ii*, come to our presentation "On Weak Truthmaking" (FOUST 2019)!

[1] Note that the two criteria below, which we have numbered in order to discuss them, are actually presented contiguous to each other in [Par99], while only the second criterion is mentioned in [Par05].

# Weak truthmaking

Rephrasing the defintion of truthmaking in a modal settin, we have:

> *(WT) t is a weak truthmaker for proposition that $\varphi$ at w iff t is intrinsically such that $\varphi$ at w.*

For a detalied analysis, come to our presentation “On Weak Truthmaking” (FOUST 2019)!

# Truthmakers and ontological commitment

Ontological analysis and selection of the domain:

- Start with a natural language sentence about the domain of interest.
- Postulate/investigate the weak truthmakers of the sentence (depending also on the level of granularity required).
- Such reifications make the ontological commitment of the theory explicit.

# Truthamaking and onlological analysis

- By categorising the types of truthmakers of certain sencentecs, we can introuce an analysis of proeprties (unary predicates) and relations (*n*-ary predicates).

# TRUTHMAKING OF PREDICATIVE SENTENCES

- **Descriptive property** : hold in viriture of *how* the arguments are.

  The truthmakers of $P(a)$ where $P$ is *descripive* are e.g. a quality of $a$ or a relational quality of $a$.

  E.g. $Red(a)$, the color of $a$
  E.g. $Loves_b(a)$, the feeling of $a$ for $b$
  .

- **Non-descriptive** : not-descriptive.

- **Internal (or intrinsic) property** : hold in virture of internal (or intrinsic) features of the argument.

  The truthmakers of $P(a)$ where $P$ is *internal* is e.g. a quality of $a$, a part of $a$.

  E.g. $Red(a)$, the color of $a$
  E.g. $SnubNosed(a)$, the nose of $a$.

- **External property** : not internal.

# TRUTHMAKING AND PROPERTIES

| | Descriptive | Non-Descriptive |
|---|---|---|
| Internal | √<br>- *Being red*<br>- *Having a big nose* | X<br>- *Being an apple*<br>√<br>- *Having a nose* |
| External | √<br>- *Loving Mary*<br>- *Being married with Mary*<br>- *Being loved by Mary* | √<br>- *Being a father*<br>- *Being born in China*<br>- *Being part of a car* |

**√: deserving reified truthmakers**

# Truthmaking of relational sentences

Concerning relations, we are interested mainly in the following distinctions:

- **internal** relations
- **external** relations
- **descriptive** relations
- **non-descriptive** relations

# Internal relations: a long philosphical debate

Moore

- *Internal*$_1$: a relation that holds just in virtue of mere existence of relata.

  E.g. essential parhood.

- *extenral*$_1$: not *internal*$_1$

Russell

- *Internal*$_2$: a relation that is defined in terms of the intrinsic properties of its relata

  E.g.$tallerThan(x, y)$

- *extenral*$_2$: not *internal*$_2$

  E.g.$tallerThan(x, y)$

# GUIZZARDI ORIGNAL DISTINCTION[2]

- A **Material relation** holds in virtue of the existence of a *relator* composed of particularized properties called *modes* that inhere in the relata and are existentially dependent on a common external entity called *foundation*.

  E.g. $marriedTo(x, y)$, $enrolledIn(x, y)$.

  Note: this is more strictive than being " not ian nternal relation" (e.g. not defined in terms of internal properties).

- A **formal relation** is a a relation that is not material.

  E.g. $tallerThan(x, y)$, $heavierThan(x, y)$.

[2] [Gui05]

# Types of relations: descriptive vs non-descriptive

- A **descriptive relation** holds in virtue of *how* their arguments are: $heavierThan(x, y)$; $worksFor(x, y)$.

  Their weak truthmakers are qualities inhering in the arguments or in their parts. They may have objects or events as strong truthmakers.

- A **non-descriptive relation** holds in virtue of what their arguments are, i.e., their nature and structure: $partOf(x, y)$; $dependentOn(x, y)$; $inheresIn(x, y)$; $bornIn(x, y)$.

  Their weak truthmakers (if any) are not qualities inhering in the relata or their parts. They may have objects or events as strong truthmakers.

# Types of relations : intenral vs extenral

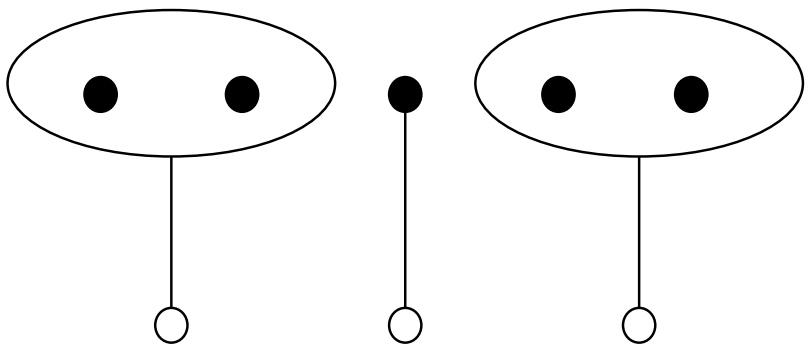
- An **internal relation** is such that none of its weak truthmakers components (e.g. parts) is existentially dependent on more than one relata.

  E.g. $heavier(x, y)$.

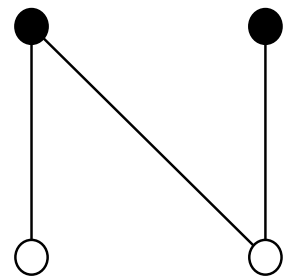
- An **external relation** is such that some of its weak truthmakers components (e.g. parts) are not internal to exactly one argument.

  E.g. $worksFor(x, y)$, $bornIn(x, y)$.

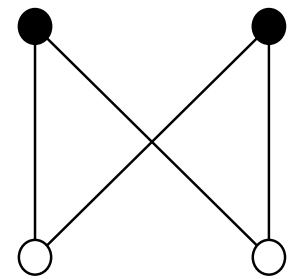
# Internal and extenral relations



(a) Internal relations



(b) External (one-sided)



(c) External (two-sided)

# A PRELIMINARY THEORY OF TRUTHMAKING OF RELATIONAL SENTENCES

- Providing an exhustive account of the types of relations is philosophically challenging.
- We recently proposed a preliminary theory of relations within the first-order (modal) formalisation of UFO.
- [Fon19]

# A PRELIMINARY THEORY OF RELAITONS (ER 2019)

| | | Descriptive | Non-Descriptive |
|---|---|---|---|
| Internal | | Comparative relations among objects — *Heavier-than*, *Smaller-than*, *Brighter-color-than* | Existential dependence — *Inheres-in*, *Mediates*, *Externally-dependent-on* |
| External | One-sided relations | *Loves, Admires* | Historical relations — *Descendent-of*, *Born-in* |
| | Double-sided relations | *Married-with, Employed-by* | |

# A PRELIMINARY THEORY OF RELAITONS (ER 2019) I

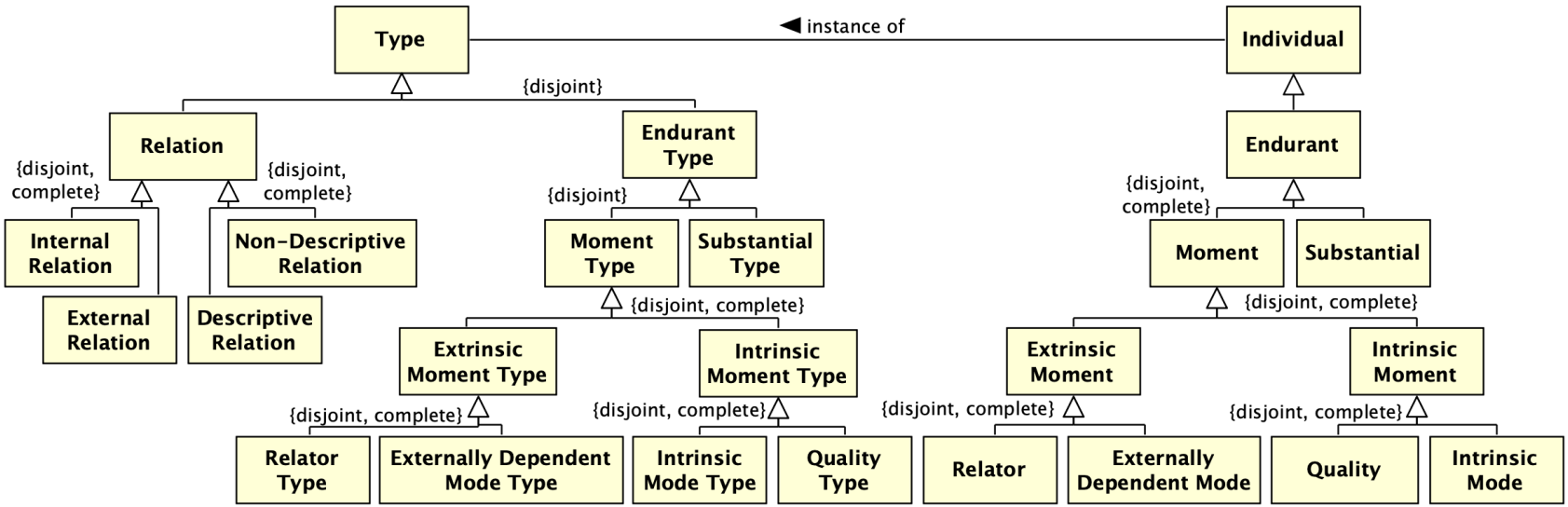



FIGURE: Taxonomy of UFO Types.

# A PRELIMINARY THEORY OF RELAITONS (ER 2019) II

We reify relations and we write $\langle x_1, \ldots, x_n \rangle :: r$ for the instantiation of an $n$-ary relation $r$ by $x_1, \ldots, x_n$

**a13** $\texttt{Type}(p) \wedge \Box(x :: p \leftrightarrow \exists m,t(\texttt{IntrinsicMoment}(m) \wedge \texttt{IntrinsicMomentType}(t) \wedge m :: t \wedge \texttt{inheresIn}(m,x)) \rightarrow \texttt{IntrinsicProperty}(p)$

**a14** $\texttt{der}(x,y) \rightarrow (\texttt{Relation}(x) \vee \texttt{Type}(x)) \wedge (\texttt{Relation}(y) \vee \texttt{Type}(y))$

**a15** $\texttt{Internal}(r) \leftrightarrow \forall xy.(\Diamond\langle x,y\rangle :: r \rightarrow \exists pp'.(\texttt{IntrinsicProperty}(p) \wedge \texttt{IntrinsicProperty}(p') \wedge \texttt{der}(r,p) \wedge \texttt{der}(r,p') \wedge x :: p \wedge y :: p'))$

**a16** $\texttt{Descriptive}(r) \leftrightarrow \forall x_1x_2.(\Diamond\langle x_1,x_2\rangle :: r \rightarrow \exists z.(\texttt{MomentType}(z) \wedge \texttt{der}(r,z) \wedge \exists m.(\texttt{ExtrinsicMoment}(m) \wedge m :: z \wedge \bigvee_{i,j\in\{1,2\}}^{i\neq j}(\texttt{inheresIn}(m,x_i) \wedge \texttt{ed}(m,x_j))) \vee \exists m_1m_2.((\bigwedge_{i\in\{1,2\}}(\texttt{IntrinsicMoment}(m_i) \wedge m_i :: z \wedge \texttt{inheresIn}(m_i,x_i))))))$

**t1** $\texttt{Descriptive}(r) \wedge \texttt{External}(r) \wedge \Diamond\langle x_1,x_2\rangle :: r \rightarrow \exists xm.(\texttt{MomentType}(x) \wedge \texttt{ExtrinsicMoment}(m) \wedge \texttt{der}(r,x) \wedge m :: x \wedge \bigvee_{i,j\in\{1,2\}}^{i\neq j}(\texttt{inheresIn}(m,x_i) \wedge \texttt{ed}(m,x_j))$

# A PRELIMINARY THEORY OF RELAITONS (ER 2019) III

Relators:

**a17** $\texttt{foundedBy}(x,y) \rightarrow (\texttt{ExtrinsicMoment}(x) \wedge \texttt{Event}(y))$

**a18** $\texttt{ExtrinsicMoment}(x) \rightarrow \exists! y\ \texttt{foundedBy}(x,y)$

**a19** $\texttt{Relator}(x) \leftrightarrow \exists mnyze.(\texttt{Edm}(m) \wedge \texttt{inheresIn}(m,y)\ \wedge\ \texttt{Edm}(n) \wedge \texttt{inheresIn}(n,z) \wedge \texttt{P}mx \wedge \texttt{P}nx \wedge m \neq n \wedge y \neq z \wedge \texttt{foundedBy}(m,e) \wedge \texttt{foundedBy}(n,e) \wedge \texttt{ed}(m,z) \wedge \texttt{ed}(n,y))$

**a20** $\texttt{mediates}(x,y) \leftrightarrow \texttt{Relator}(x) \wedge \texttt{Endurant}(y) \wedge \exists z.(\texttt{Edm}(z) \wedge \texttt{inheresIn}(z,y) \wedge \texttt{P}zx)$

**t2** $\texttt{Relator}(x) \rightarrow \exists yz.(\texttt{mediates}(x,y)\ \wedge \texttt{mediates}(x,z) \wedge y \neq z)$

# Summing up

- We presented Quine's criterion for ontological commitment, which is in fact designed for predicative languages.
- We presented a few observations to show that Quine's view is not sufficient to capture ontological commitments.
- We presented Armstrong's view of truthmaking for ontologcial commitment.
- We discussed in partuclar Parson's *weak* truthmaking.
- We concluded discussing candidates for truthmakers for predicative sentences (properties and relations).

# References I


David Malet Armstrong.

*Truth and truthmakers*.
Cambridge University Press, 2004.

John Bigelow.

*The reality of numbers: A physicalist's philosophy of mathematics*.
Oxford University Press, 1988.

Phillip Bricker.

Ontological commitment.
In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, winter 2016 edition, 2016.

Donald Davidson.

The Logical Form of Action Sentences.
In N. Rescher, editor, *The Logic of Decision and Action*. University of Pittsburgh Press, 1967.

Donald Davidson.

*Essays on Actions and Events*.
Oxford University Press, 2001.

Fonseca, C. M., Porello, D., Guizzardi, G., Almeida, J. P., Guarino, N.

Relations in Ontology-Driven Conceptual Modeling.
In *Proc.38th ER*, 2019.

Nicola Guarino and Giancarlo Guizzardi.

Relationships and Events: Towards a General Theory of Reification and Truthmaking.
In *Proc.15th AI*IA*, 2016.

# References II


Giancarlo Guizzardi.

*Ontological foundations for structural conceptual models*.
PhD thesis, CTIT, Centre for Telematics and Information Technology, Enschede, 2005.

Fraser MacBride.

Truthmakers.
In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, winter 2018 edition, 2018.

Friederike Moltmann.

*Abstract objects and the semantics of natural language*.
OUP Oxford, 2013.

Josh Parsons.

There is no ”truthmaker” argument against nominalism.
*Australasian Journal of Philosophy*, 77(3):325–334, 1999.

Josh Parsons.

Truthmakers, the past, and the future.
In Helen Beebee and Julian Dodd, editors, *Truthmakers: The Contemporary Debate*. Clarendon Press, 2005.

Willard V Quine.

On what there is.
*The Review of Metaphysics*, pages 21–38, 1948.

Willard Van Orman Quine.

Events and reification.
*Actions and events: Perspectives on the philosophy of Donald Davidson*, pages 162–171, 1985.

# References III


Stephen Read.

Truthmakers and the disjunction thesis.
*Mind*, 109(433):67–80, 2000.

Greg Restall.

Truthmakers, entailment and necessity.
1996.

Greg Restall.

Modelling truthmaking.
*Logique et analyse*, 43(169/170):211–230, 2000.

Barry Smith, Peter Simons, and Kevin Mulligan.

Truth-makers.
In *Truth and Truth-making*, pages 69–96. Routledge, 2014.