Helping people (besides machines) understand each other in integrated manufacturing

Nicola Guarino

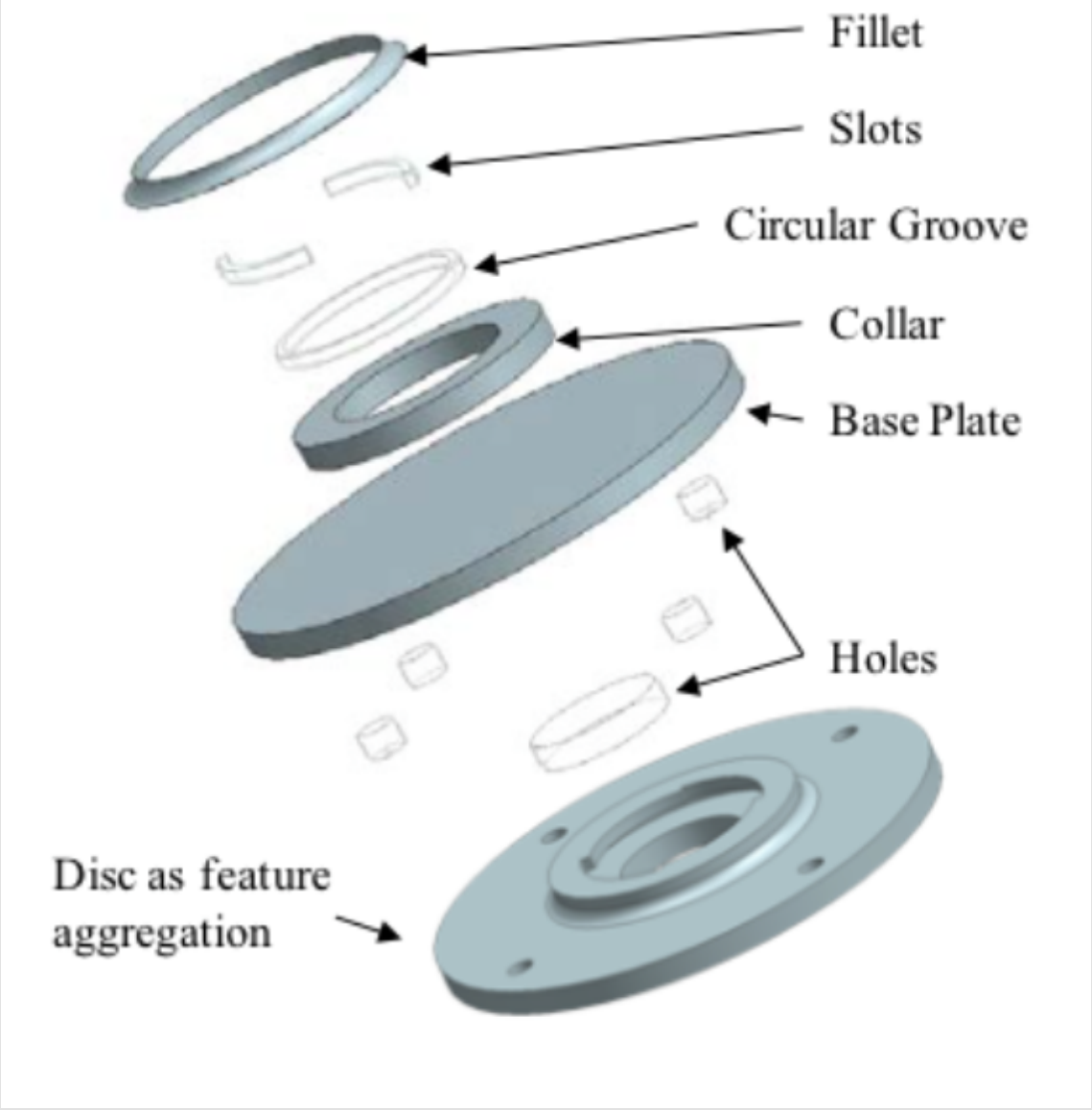
National Research Council, Institute for Cognitive Science and Technologies (ISTC-CNR)

Laboratory for Applied Ontology (LOA)

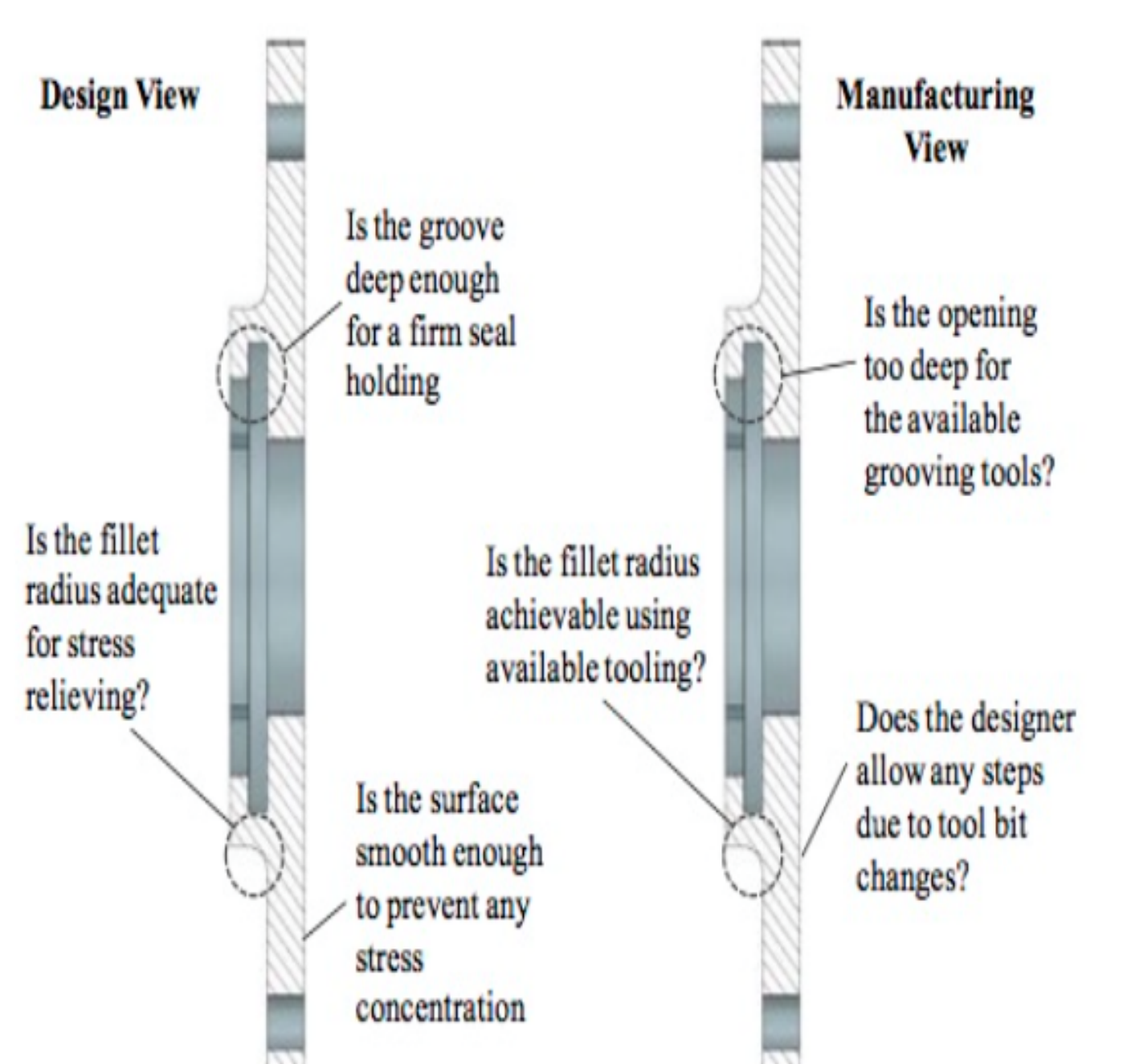
www.loa.istc.cnr.it

Ultimately, communication is among PEOPLE

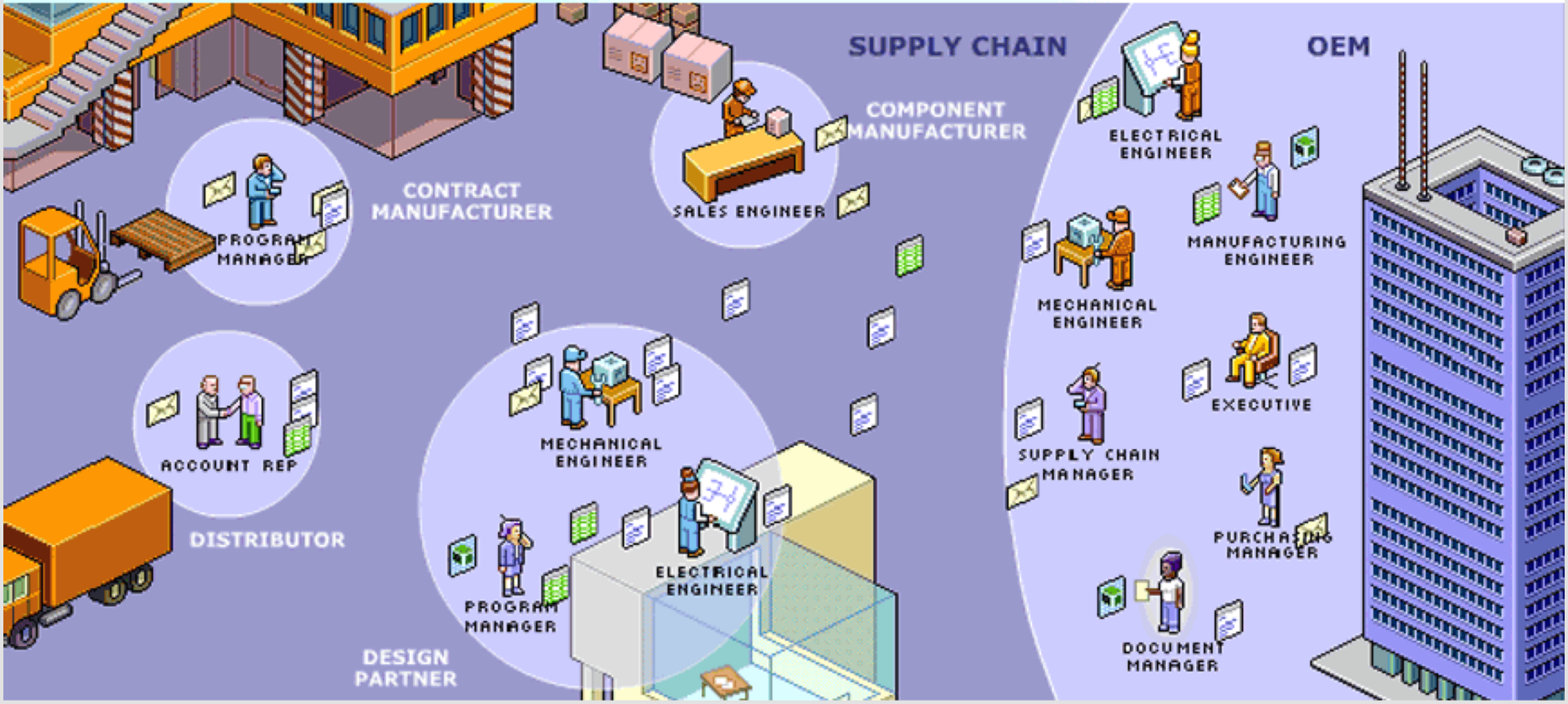
Mechanical assemblies…



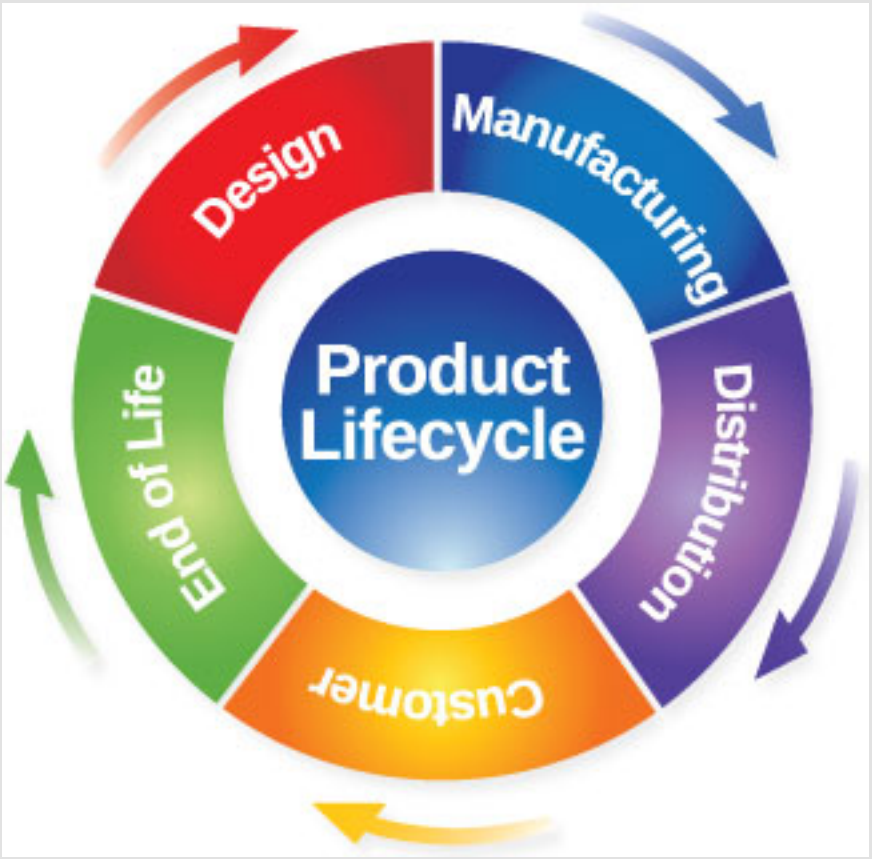
…under different perspectives



Why PLM? Feel the Pain



Product life-cycle management



The role of ontology

Carving the reality at its joints: good ontologists like good *butchers* [Plato]

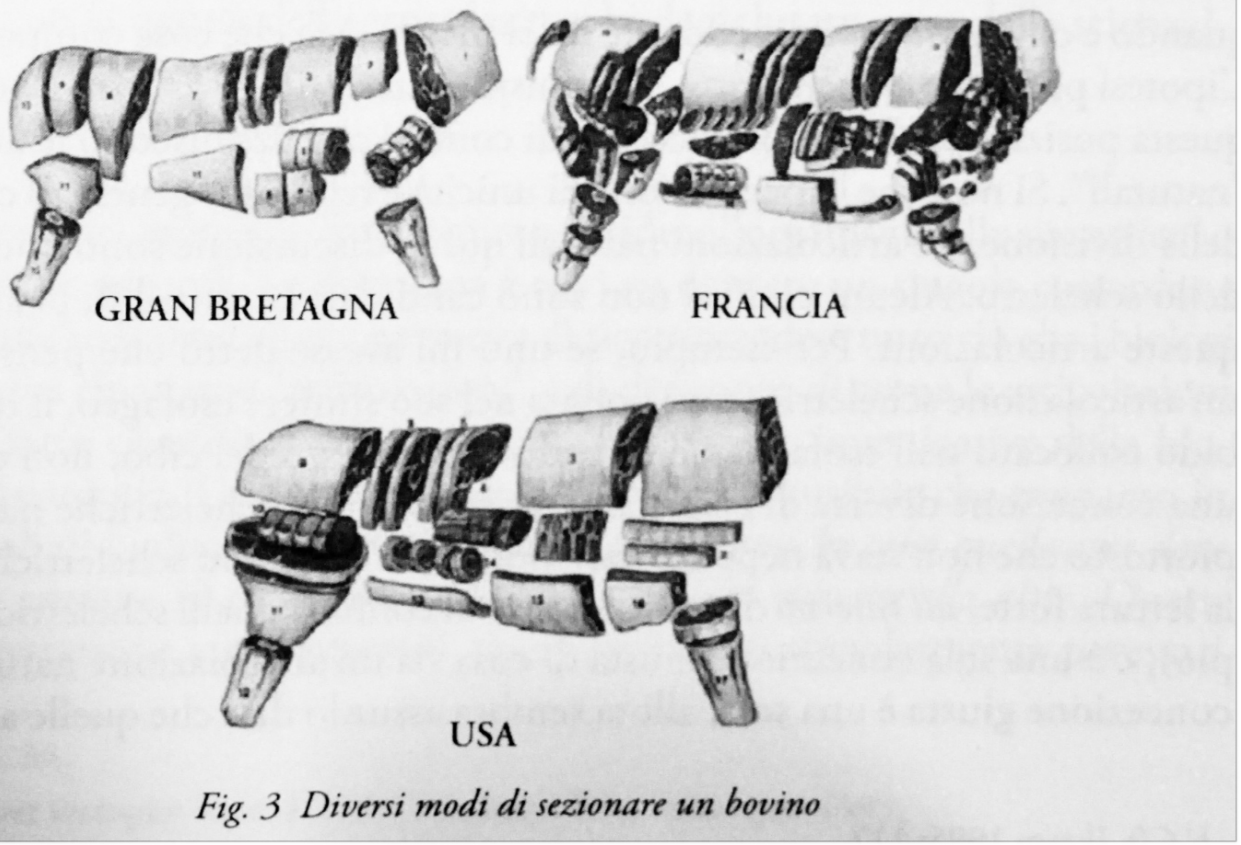


Fig. 3 Diversi modi di sezionare un bovino

…but, despite reality *resists,* still many possibilities are open!

Applied Ontology:
an emerging interdisciplinary area

Applied Ontology: an emerging interdisciplinary area

- Applied Ontology builds on *philosophy*, *cognitive science*, *linguistics* and *logic* with the purpose of understanding, clarifying, making explicit and communicating ***people's assumptions*** about the nature and structure of the world.

Applied Ontology: an emerging interdisciplinary area

- Applied Ontology builds on *philosophy*, *cognitive science*, *linguistics* and *logic* with the purpose of understanding, clarifying, making explicit and communicating ***people's assumptions*** about the nature and structure of the world.

- This orientation towards ***helping people understanding each other*** distinguishes applied ontology from philosophical ontology, and motivates its ***unavoidable interdisciplinary nature***.

Applied Ontology: an emerging interdisciplinary area

- Applied Ontology builds on *philosophy*, *cognitive science*, *linguistics* and *logic* with the purpose of understanding, clarifying, making explicit and communicating ***people's assumptions*** about the nature and structure of the world.

- This orientation towards ***helping people understanding each other*** distinguishes applied ontology from philosophical ontology, and motivates its ***unavoidable interdisciplinary nature***.

ontological analysis: study of
content (of these assumptions) ***as such***
(independently of their *representation*)

Ontological analysis and conceptual modeling

Conceptual modeling is the activity of ***formally*** describing some aspects of the ***physical*** and ***social*** world around us for the purposes of ***understanding*** and ***communication***

(John Mylopoulos)

The problem: subtle distinctions in meaning

The problem: subtle distinctions in meaning

The e-commerce case:

"Trying to engage with too many partners too fast is one of the main reasons that ***so many online market makers have foundered***"

The transactions they had viewed as simple and routine actually involved many ***subtle distinctions in terminology and meaning***"

Harvard Business Review, October 2001

Subtle distinctions in meaning...

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?
- What is an ***application*** to a public administration?

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?
- What is an ***application*** to a public administration?
- What is a ***service***?

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?
- What is an ***application*** to a public administration?
- What is a ***service****?*
- What is a ***working place***?

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?
- What is an ***application*** to a public administration?
- What is a ***service****?*
- What is a ***working place***?
- What is an ***unemployed person***?

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?
- What is an ***application*** to a public administration?
- What is a ***service****?*
- What is a ***working place***?
- What is an ***unemployed person***?
- What is a ***book****?*

Subtle distinctions in meaning...

- What is the ***function*** of an artefact?
- What is an ***application*** to a public administration?
- What is a ***service****?*
- What is a ***working place***?
- What is an ***unemployed person***?
- What is a ***book****?*

The key problems

- content-based information access *(**semantic matching**)*
- content-based information integration *(**semantic integration**)*

The need for clarifying common terms

- At least 3 different senses of “oil” **implicitly** used in a large oil company
  - oil present in the soil
  - extracted oil
  - refined oil
- Several, conflicting notions of “behavior” and “function” used in engineering
  - systemic function
  - design function
  - use function…

Semantic Interoperability is considered to be ***the problem of this decade***…[currently] costing productivity, lives and billions of dollars annually…the overall human and financial cost to society from our failure to share and reuse information is many times the cost of the systems' operation and maintenance [OMG, SIMF]

Product Classification

- U.S. Product Classification:
  - **Dolls:** Representing Only a Human-Being (12%)
  - **Toys:** Anything that does not represent only a human being (6%)

World Trade Centre insurance

Bad forms

After a rancorous trial, relief for many insurers of the twin towers

May 6th 2004 | from the print edition

IT WAS a $3.5 billion question: was the crashing of two aeroplanes into New York's twin towers in September 2001 one event or two? One, many insurers are relieved to know. On May 3rd a jury ruled that Swiss Re, the world's second-largest reinsurer, which wrote about a quarter of the coverage for the World Trade Centre, was bound by a form that classed such attacks as a single occurrence. Last week the same jury had reached a similar verdict for several Lloyd's of London syndicates and seven other insurers. The loser was Larry Silverstein, the centre's leaseholder. He had argued that another form was valid, in the hope of claiming around $7 billion for two events. Now he may get only half that.

In most disaster insurance, "occurrence" is carefully defined. Earthquake coverage typically treats all shaking

Silverstein's the loser AP

Print E-mail

Reprints & permissions

When subtle distinctions are important: *fine prints*

***An ontology is like a contract's fine print**, one of those things which require a very precise technical jargon, which you might ignore in many cases, but which **can save your business in critical situations**.*

Focusing on *content*

Do we know *what* to REpresent?

Do we know *what* to REpresent?

- ***First*** analysis,

Do we know *what* to REpresent?

- ***First*** analysis,
- ***THEN*** representation…

Do we know *what* to REpresent?

- ***First*** analysis,
- ***THEN*** representation…

Unfortunately, this is not the current practice…

Do we know *what* to REpresent?

- ***First*** analysis,
- ***THEN*** representation…

Unfortunately, this is not the current practice…

- Computer scientists have focused on the ***structure of representations*** and the ***nature of reasoning*** more than on the ***content*** of such representations

Do we know *what* to REpresent?

- ***First*** analysis,
- ***THEN*** representation…

Unfortunately, this is not the current practice…

- Computer scientists have focused on the ***structure of representations*** and the ***nature of reasoning*** more than on the ***content*** of such representations

No representation without
ontological analysis!

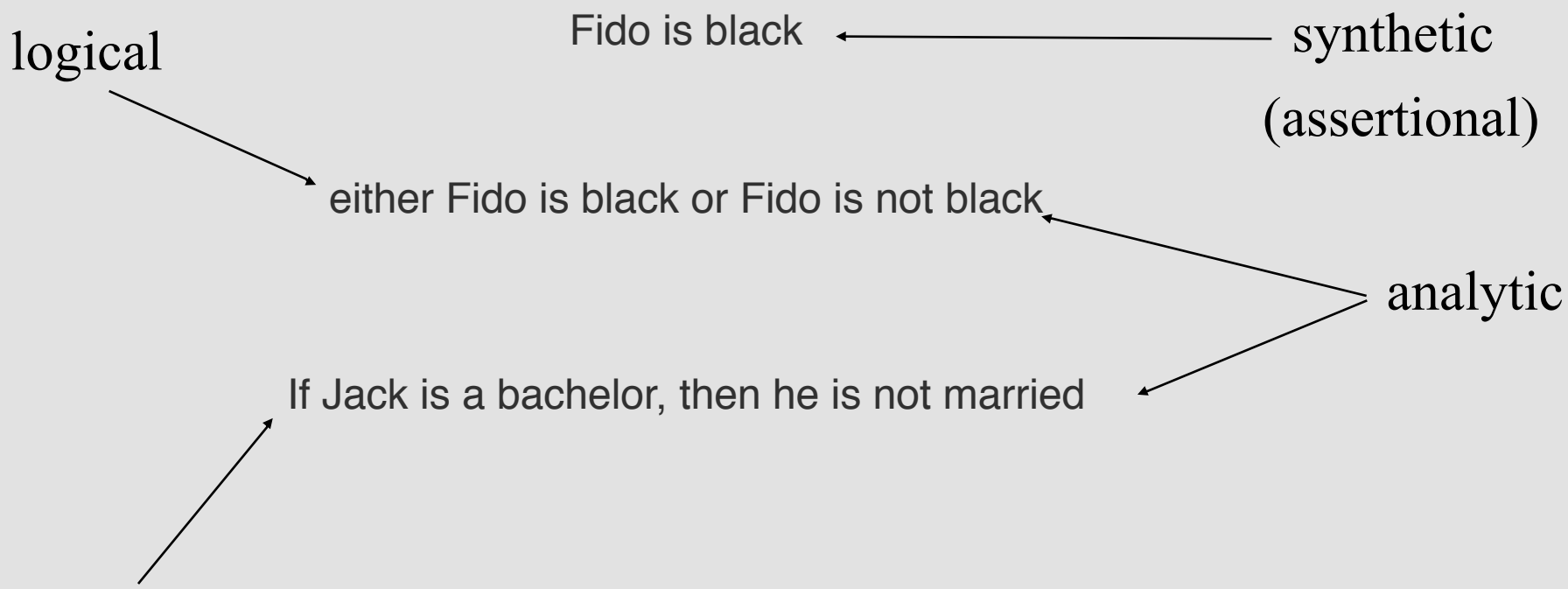
Logic is neutral about content

Logic is neutral about content

...but very useful to describe the formal structure (i.e., the *invariances*) of content

Kinds of knowledge

(Carnap - *Meaning and Necessity*)



Terminological knowledge is about relationships between ***terms*** and ***concepts***

What is an ontology

Philosophical ontologies

Philosophical ontologies

- ***Ontology***: the philosophical discipline

Philosophical ontologies

- ***Ontology***: the philosophical discipline
  - Study of ***what there is*** (being qua being...)
    ...a liberal reinterpretation for computer science:

    content *qua* content, *independently of the way it is represented*

  - Study of the ***nature*** and ***structure*** of “reality”

Philosophical ontologies

- ***Ontology***: the philosophical discipline
  - Study of ***what there is*** (being qua being...)
    ...a liberal reinterpretation for computer science:

    content *qua* content, *independently of the way it is represented*

  - Study of the ***nature*** and ***structure*** of "reality"
- ***A (philosophical) ontology:*** a structured system of entities assumed to exists, organized in categories and relations

Computational ontologies

Computational ontologies

Specific (theoretical or computational) artifacts
expressing the ***intended meaning*** of a ***vocabulary***
in terms of ***primitive*** categories and relations describing
the ***nature*** and ***structure*** of a ***domain of discourse***

Computational ontologies

Specific (theoretical or computational) artifacts
expressing the ***intended meaning*** of a ***vocabulary***
in terms of ***primitive*** categories and relations describing
the ***nature*** and ***structure*** of a ***domain of discourse***

Gruber: “Explicit and formal specifications of a ***conceptualization***”

Computational ontologies

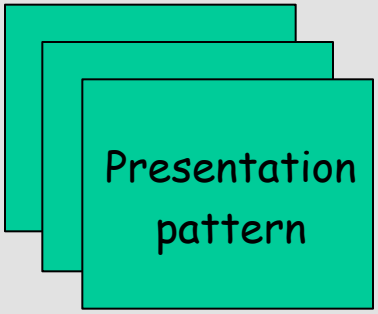
Specific (theoretical or computational) artifacts
expressing the ***intended meaning*** of a ***vocabulary***
in terms of ***primitive*** categories and relations describing
the ***nature*** and ***structure*** of a ***domain of discourse***

Gruber: "Explicit and formal specifications of a ***conceptualization***"

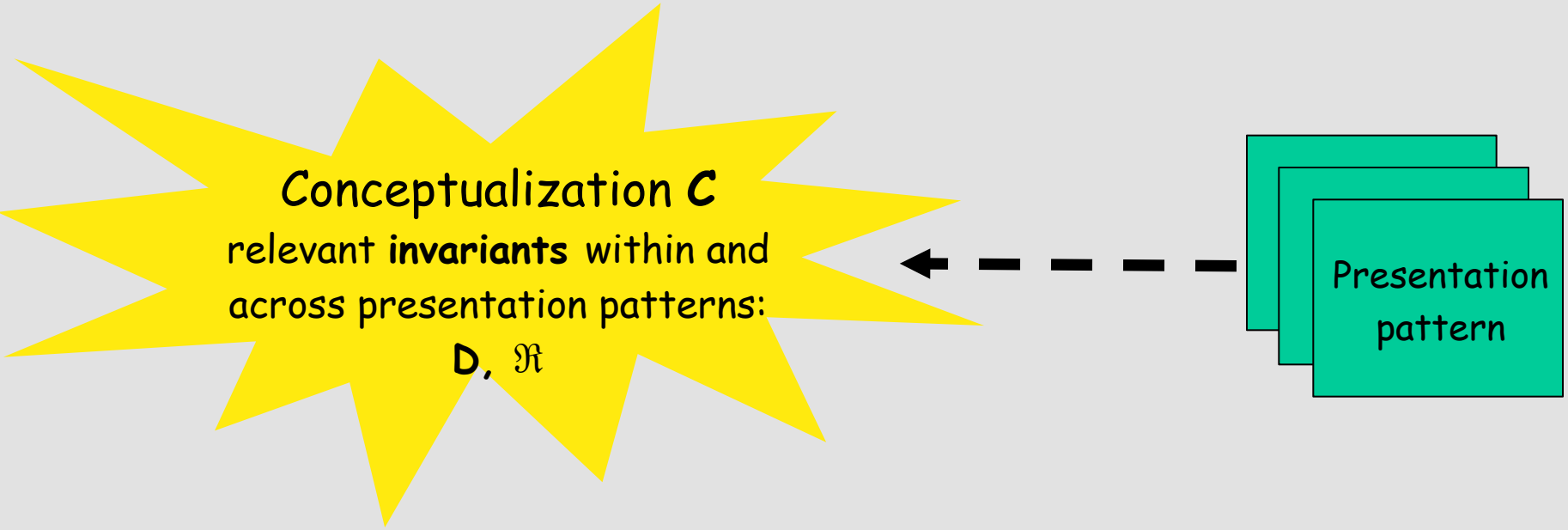
Computational ontologies, in the way they evolved, unavoidably mix
together philosophical, cognitive, and linguistic aspects.
Ignoring this ***intrinsic interdisciplinary nature***
makes them almost **useless**.

From experience to *conceptualization*

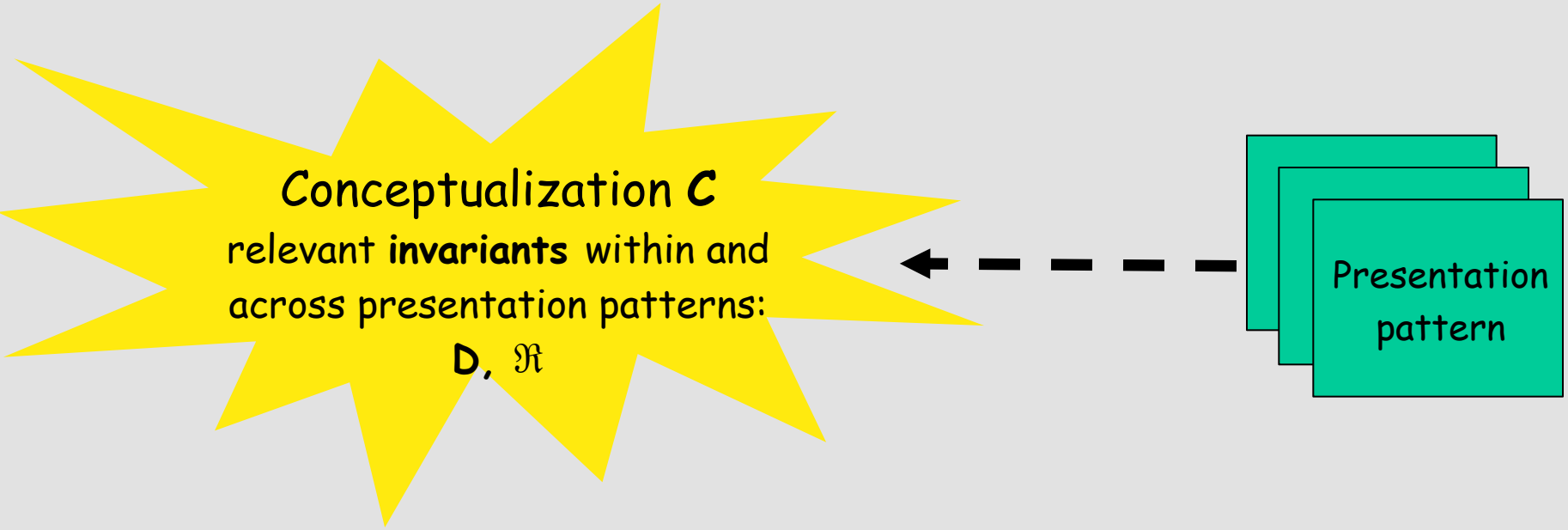
From experience to *conceptualization*



From experience to *conceptualization*

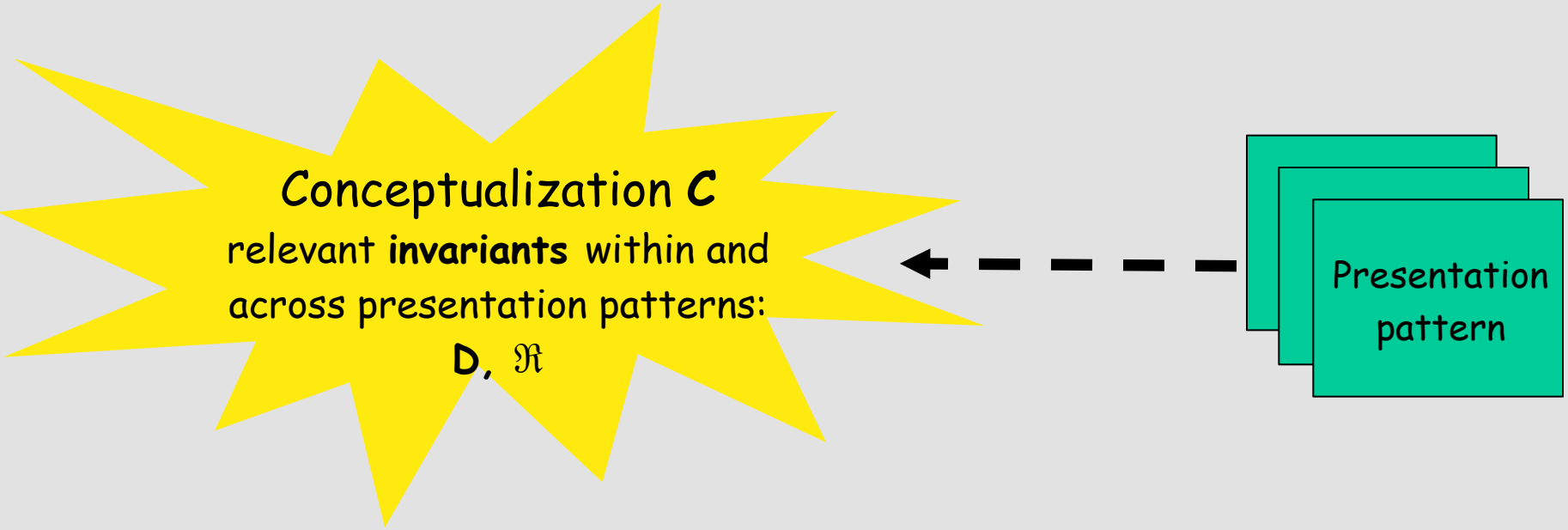


From experience to *conceptualization*



D : cognitive domain

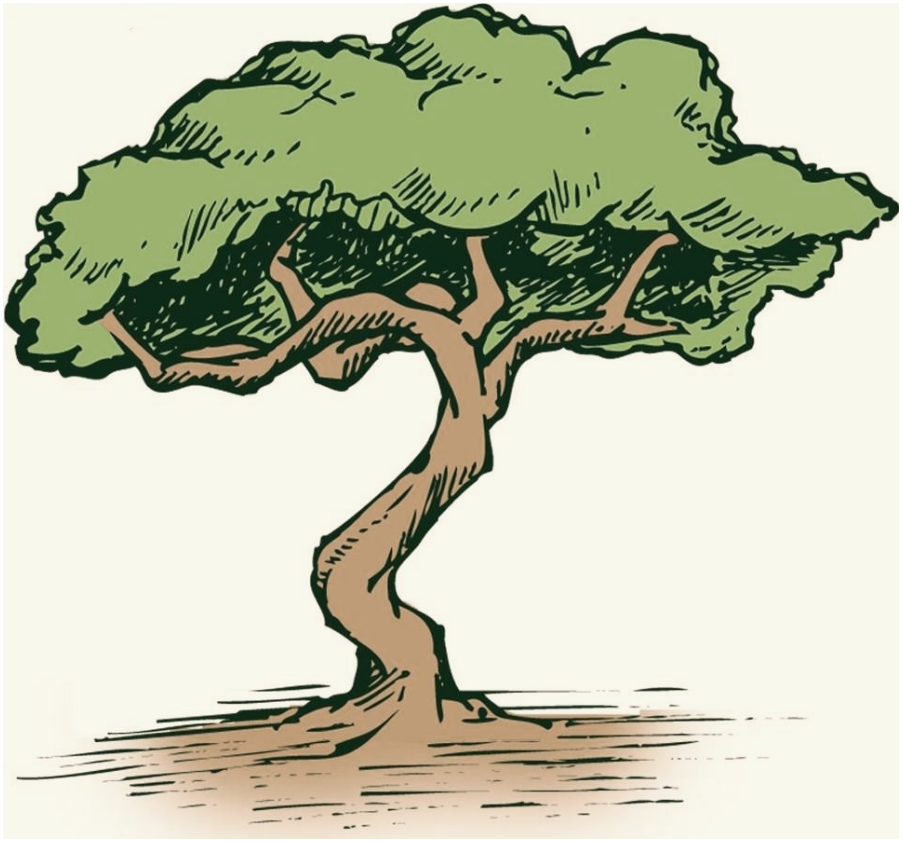
From experience to *conceptualization*



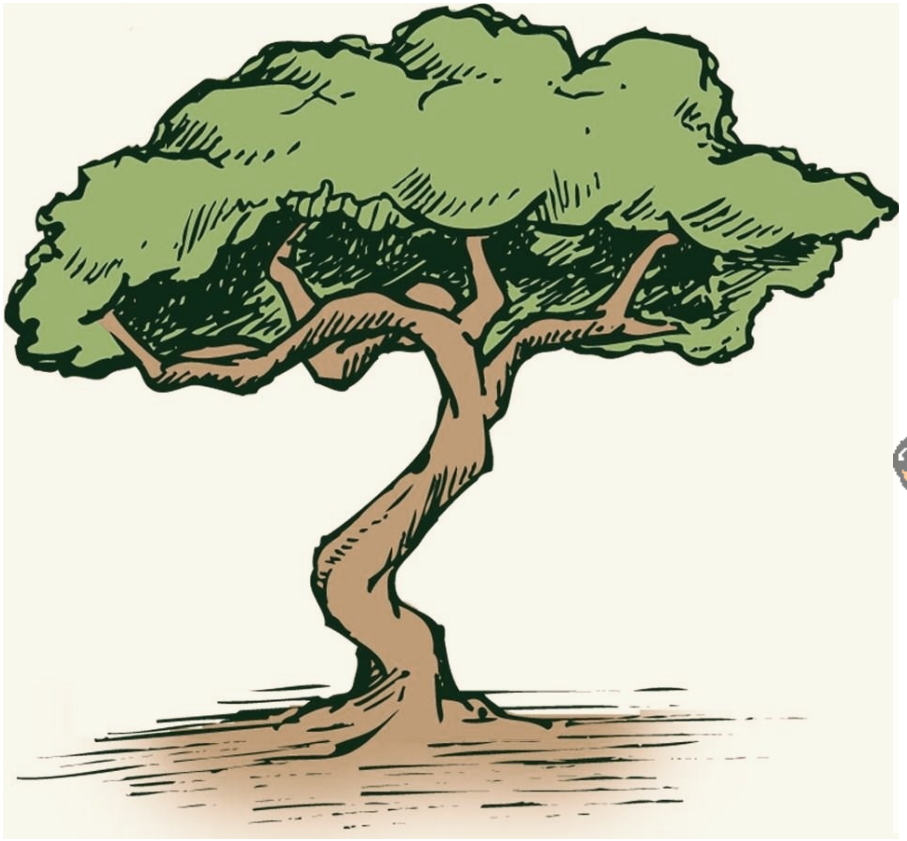
D : cognitive domain

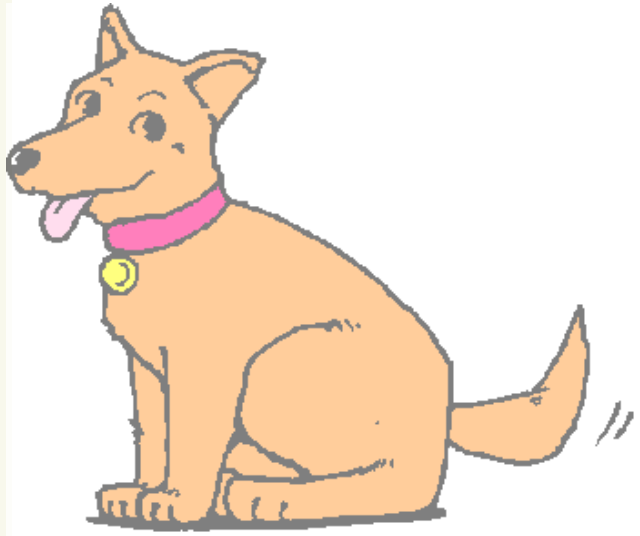
ℜ : set of *conceptual relations* on elements of D

Unity and individuation criteria

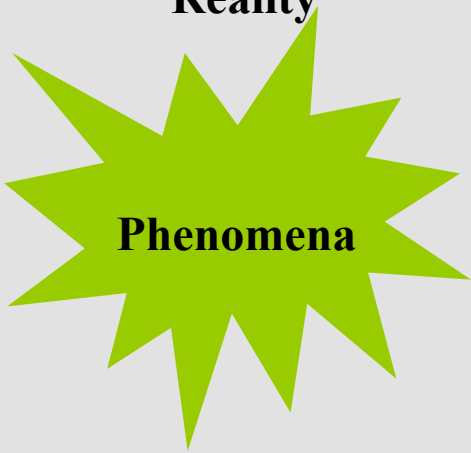


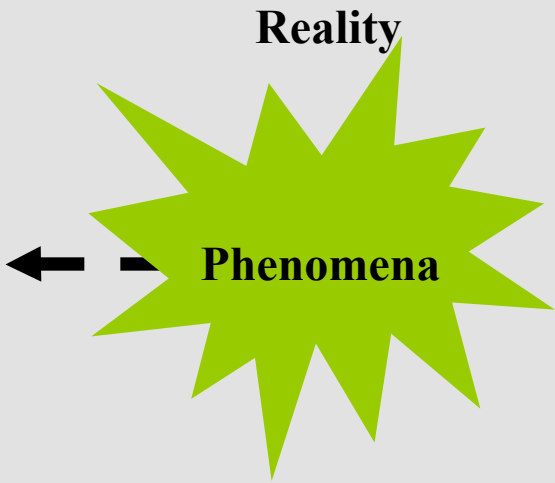
Unity and individuation criteria

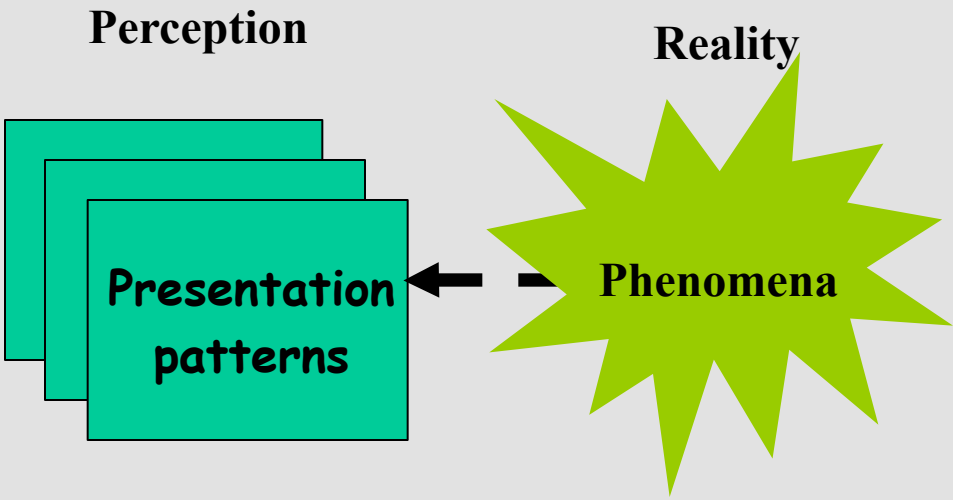


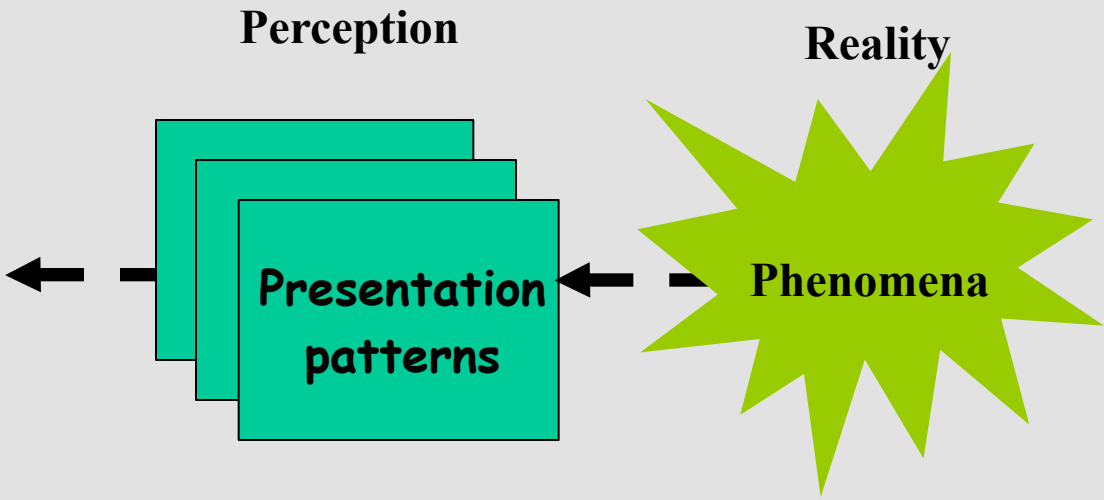


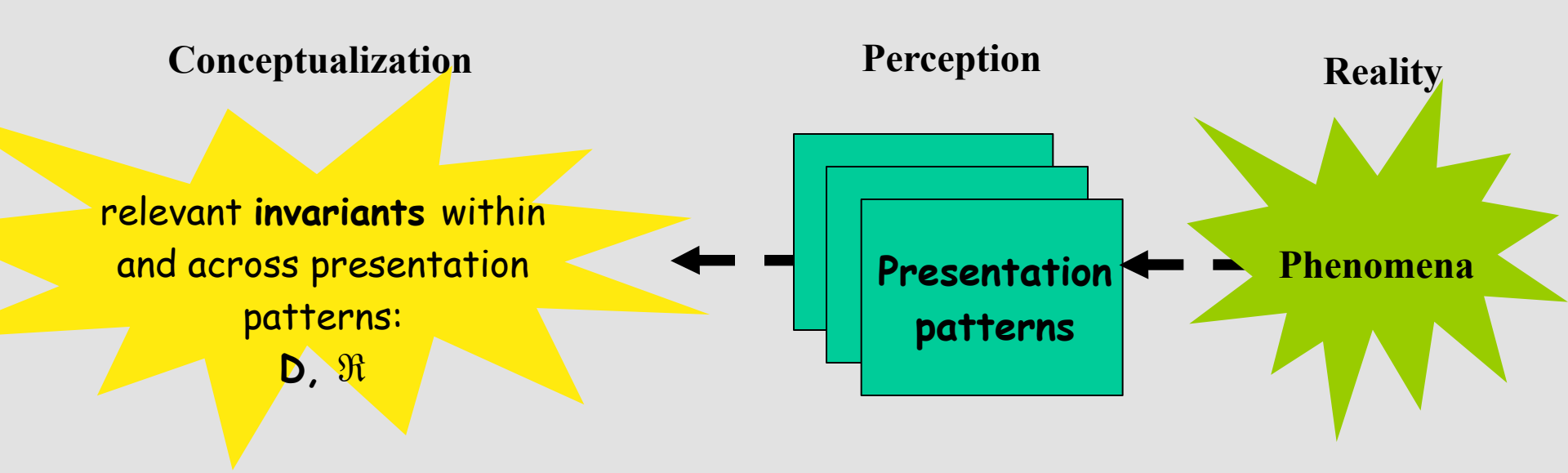
Reality

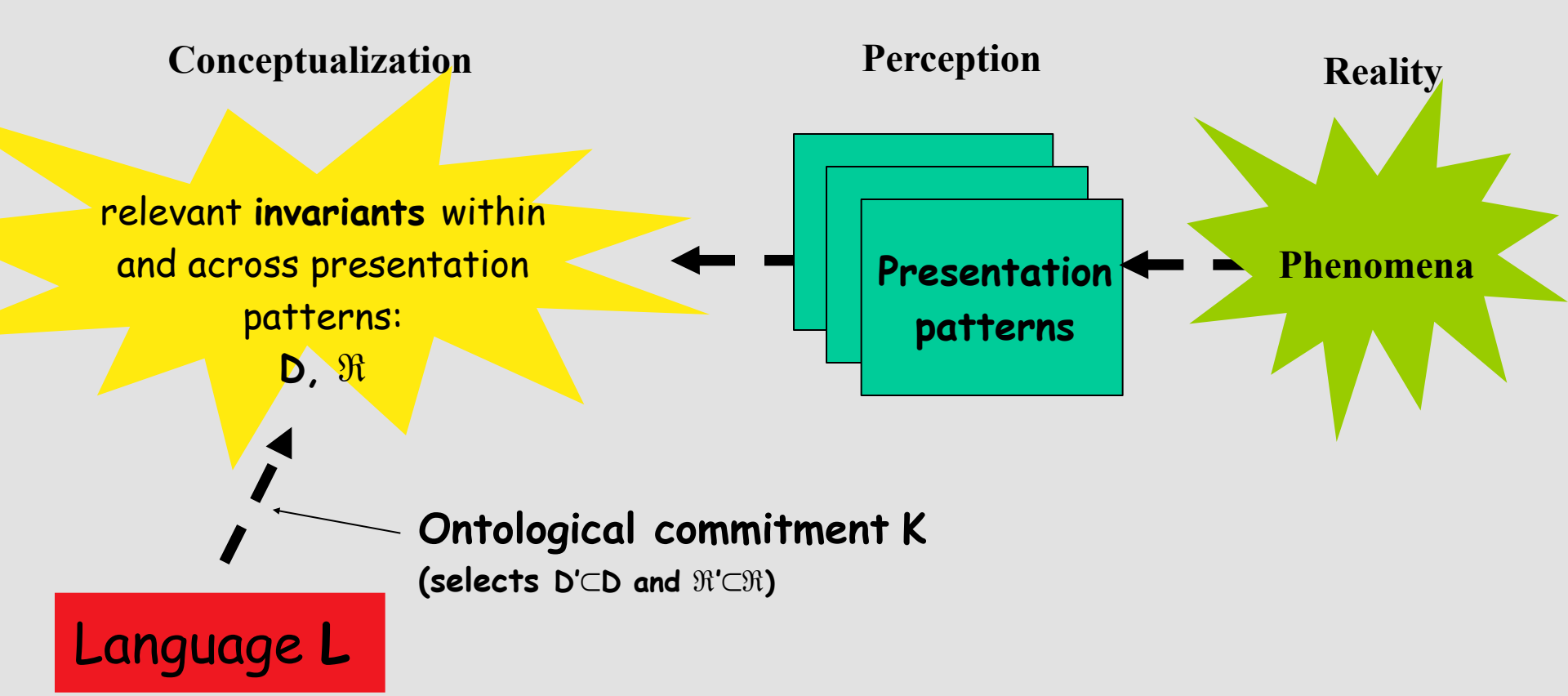


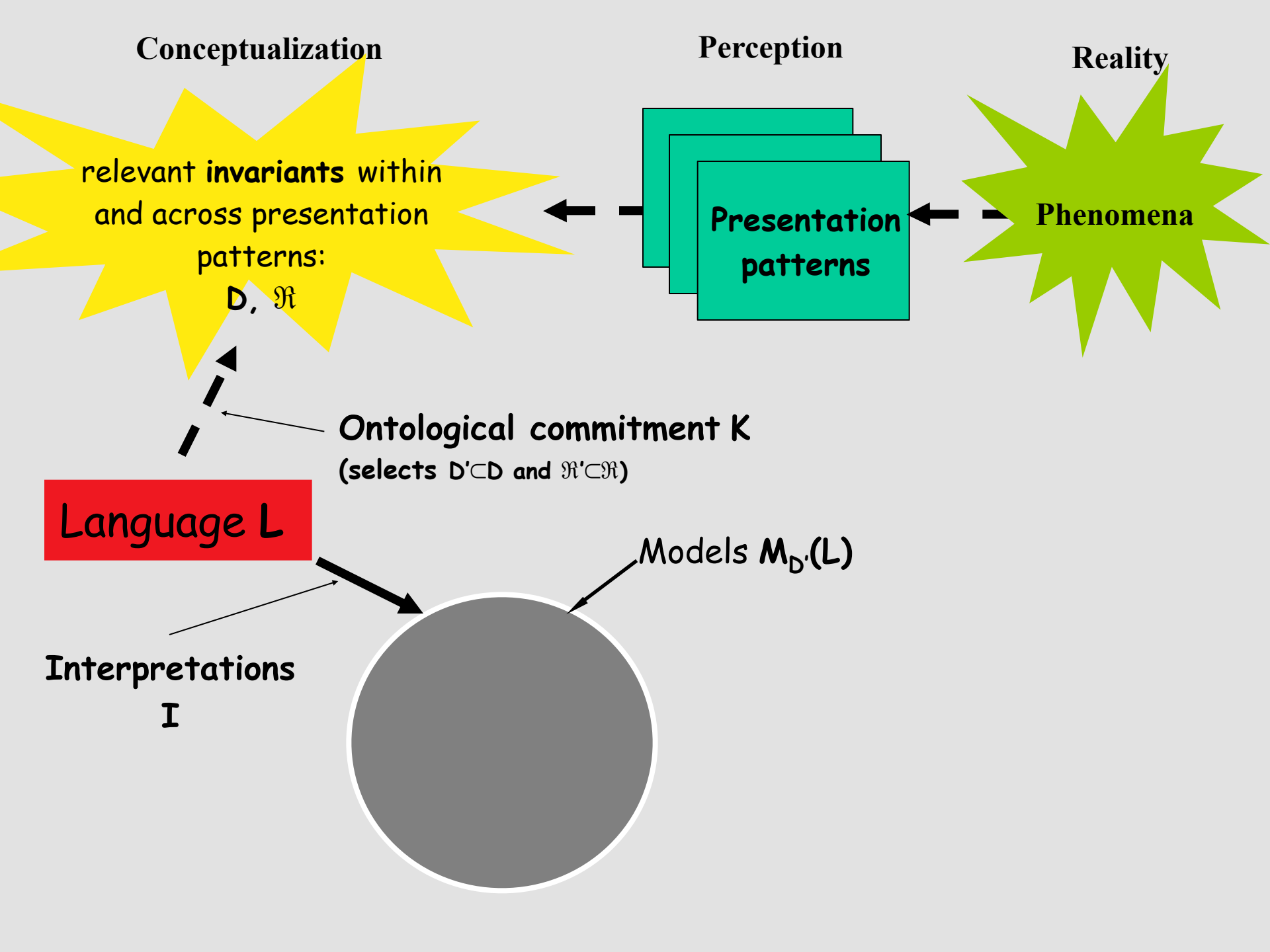

Reality
Phenomena

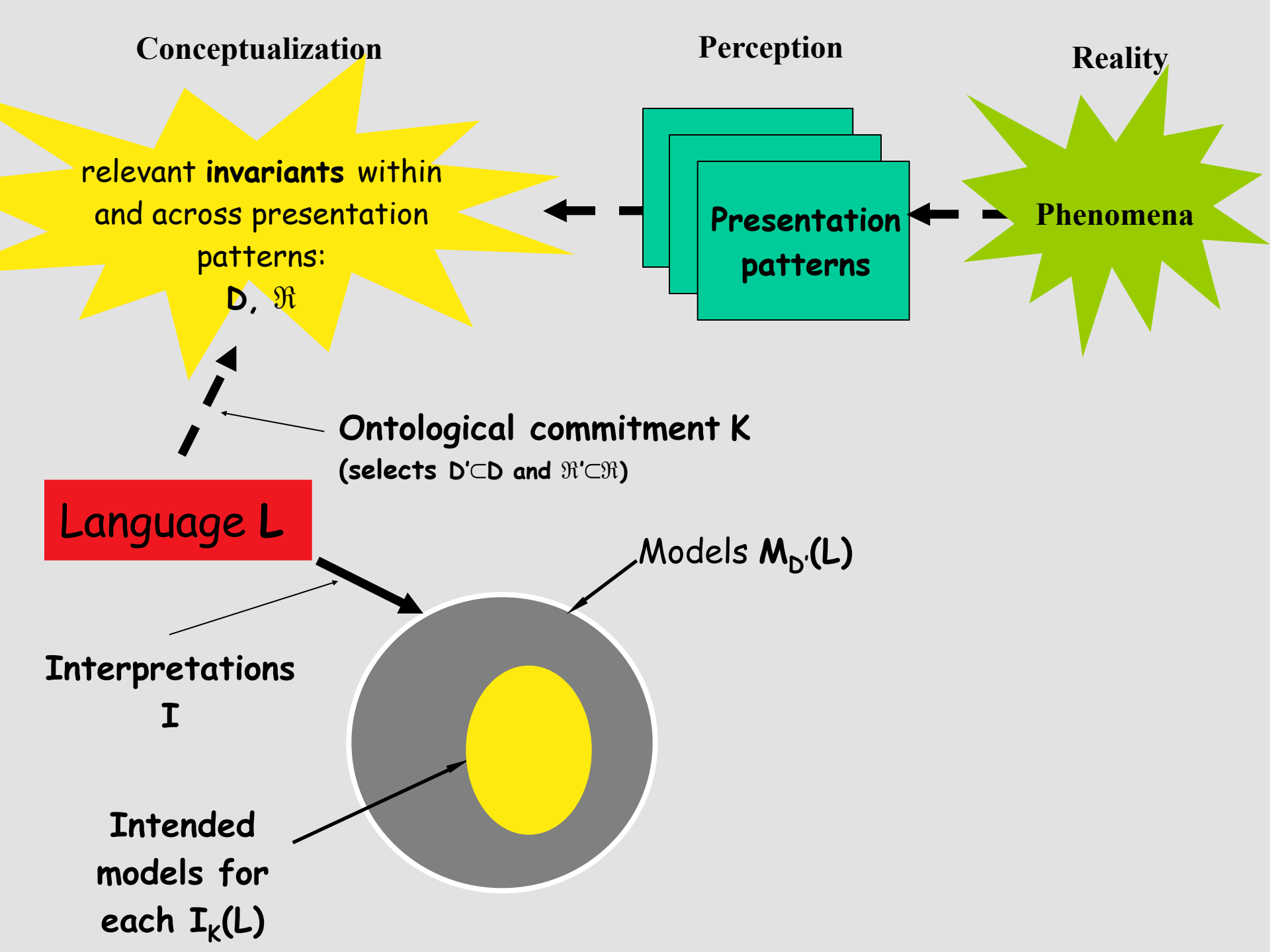

Perception
Reality
Presentation patterns
Phenomena

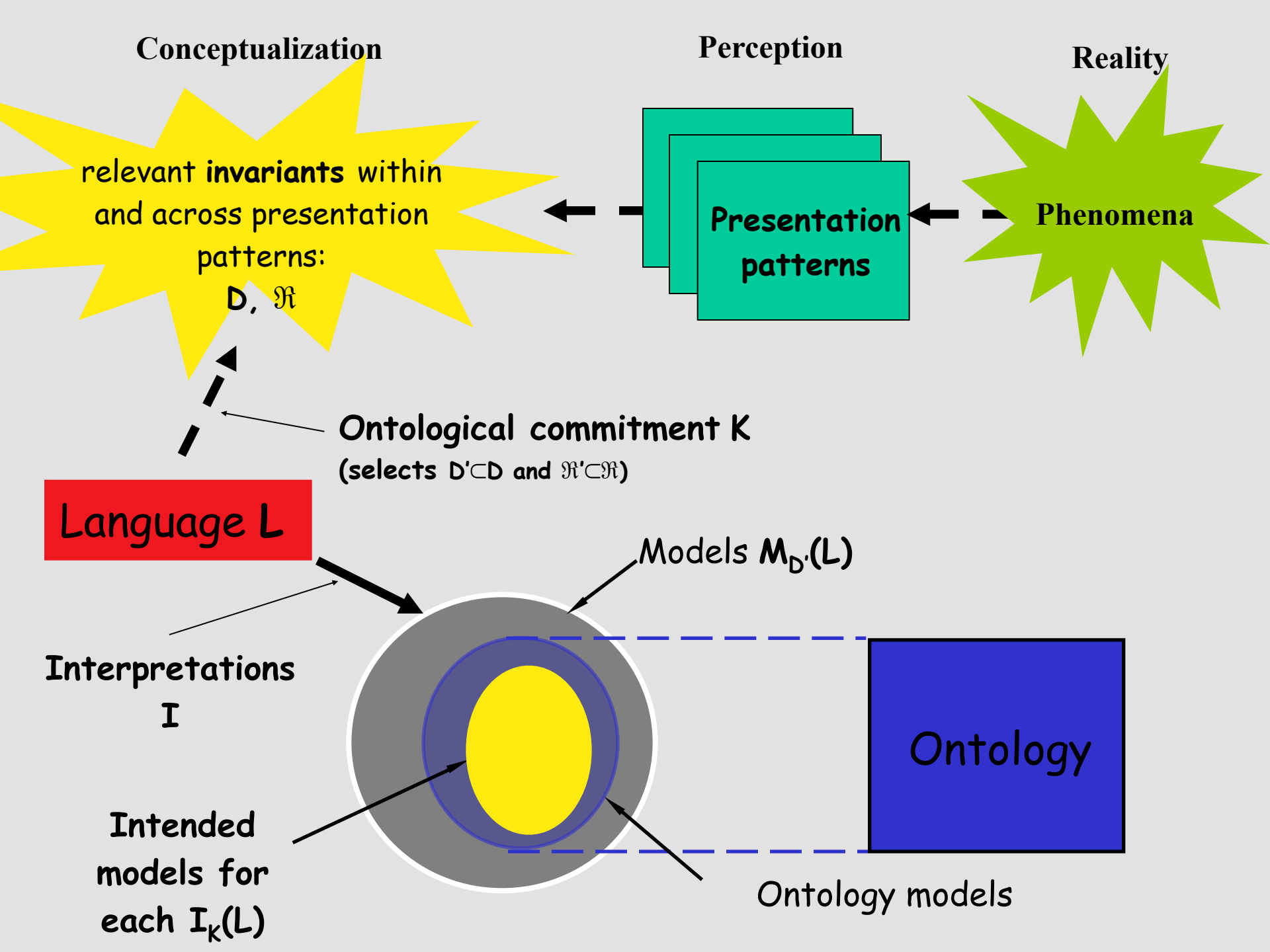

Perception
Reality
Presentation patterns
Phenomena

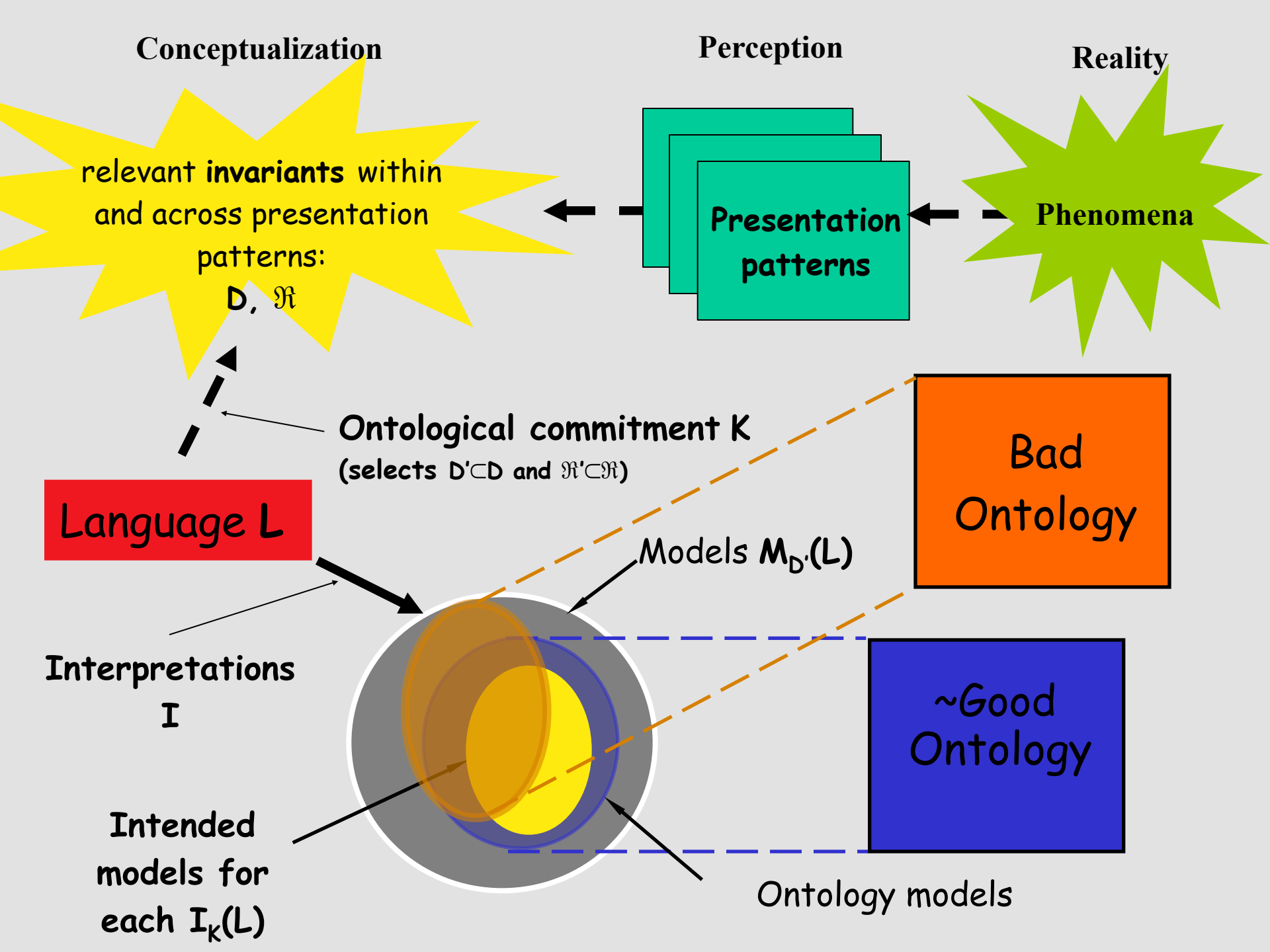

Conceptualization
Perception
Reality
relevant **invariants** within and across presentation patterns:
D, ℜ
Presentation patterns
Phenomena


Conceptualization
Perception
Reality
relevant **invariants** within and across presentation patterns:
D, ℜ
Presentation patterns
Phenomena
Ontological commitment K
(selects D'⊂D and ℜ'⊂ℜ)
Language L

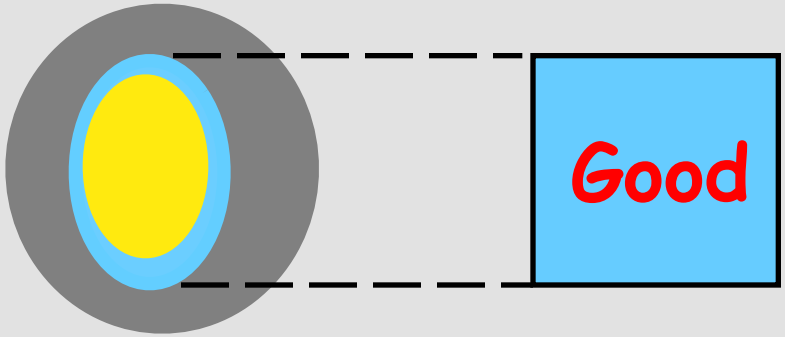

Conceptualization
Perception
Reality
relevant invariants within and across presentation patterns:
D, ℜ
Presentation patterns
Phenomena
Ontological commitment K
(selects D'⊂D and ℜ'⊂ℜ)
Language L
Models $M_{D'}(L)$
Interpretations
I


Conceptualization
Perception
Reality
relevant invariants within and across presentation patterns:
D, ℜ
Presentation patterns
Phenomena
Ontological commitment K
(selects D'⊂D and ℜ'⊂ℜ)
Language L
Models $M_{D'}(L)$
Interpretations
I
Intended models for each $I_K(L)$

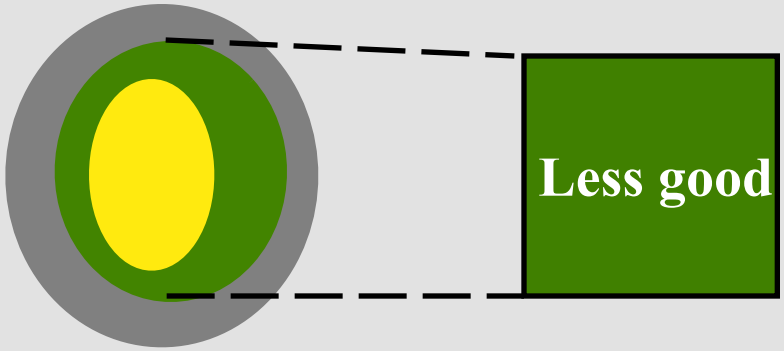

Conceptualization
Perception
Reality
relevant invariants within and across presentation patterns:
D, ℜ
Presentation patterns
Phenomena
Ontological commitment K
(selects D'⊂D and ℜ'⊂ℜ)
Language L
Models $M_{D'}(L)$
Interpretations I
Ontology
Intended models for each $I_K(L)$
Ontology models


Conceptualization
Perception
Reality
relevant invariants within and across presentation patterns: D, ℜ
Presentation patterns
Phenomena
Ontological commitment K
(selects D'⊂D and ℜ'⊂ℜ)
Language L
Models $M_{D'}(L)$
Bad Ontology
Interpretations I
~Good Ontology
Intended models for each $I_K(L)$
Ontology models

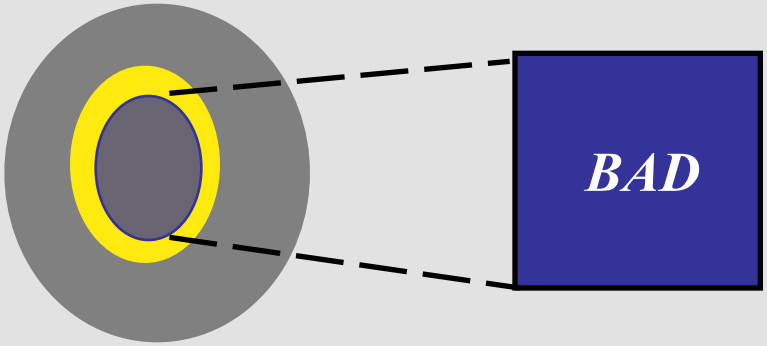
Ontology Quality: Precision and Correctness



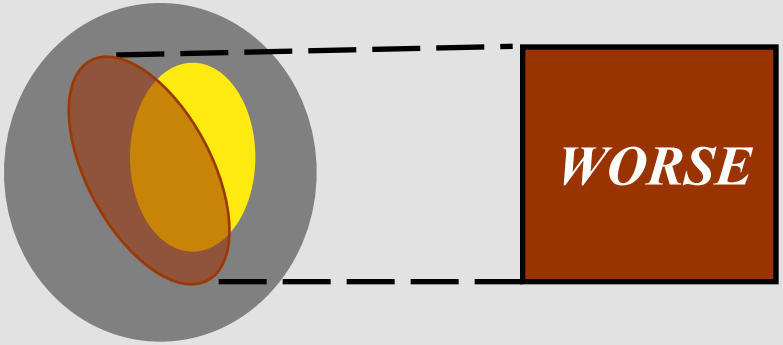
High precision, max correctness



Low precision, max correctness



Max precision, low correctness



Low precision, low correctness

Why ontological precision is important

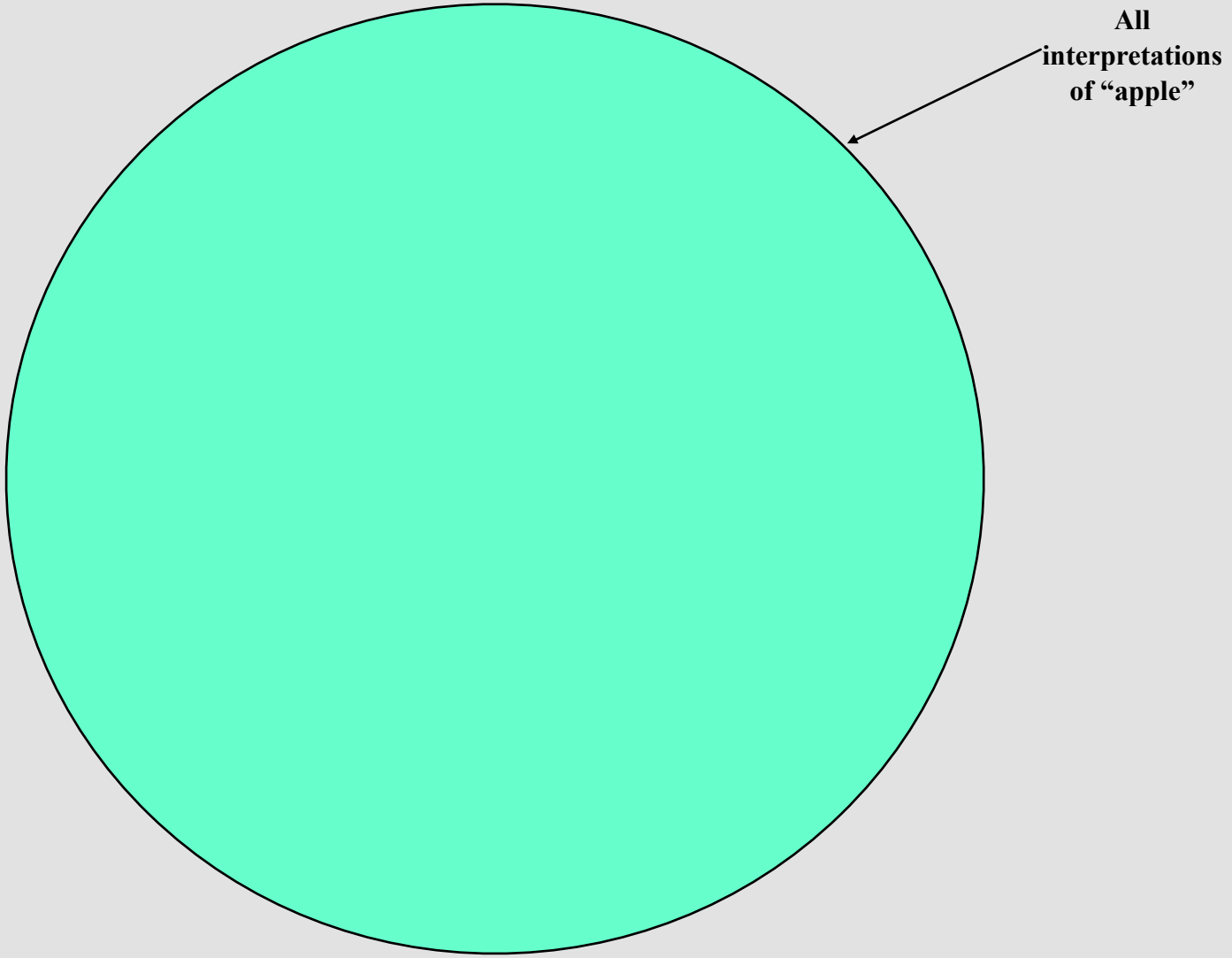
Database A: keeping track of fruit stock

Variety	Quantity
Granny Smith	12
Golden delicious	10
Stark delicious	15

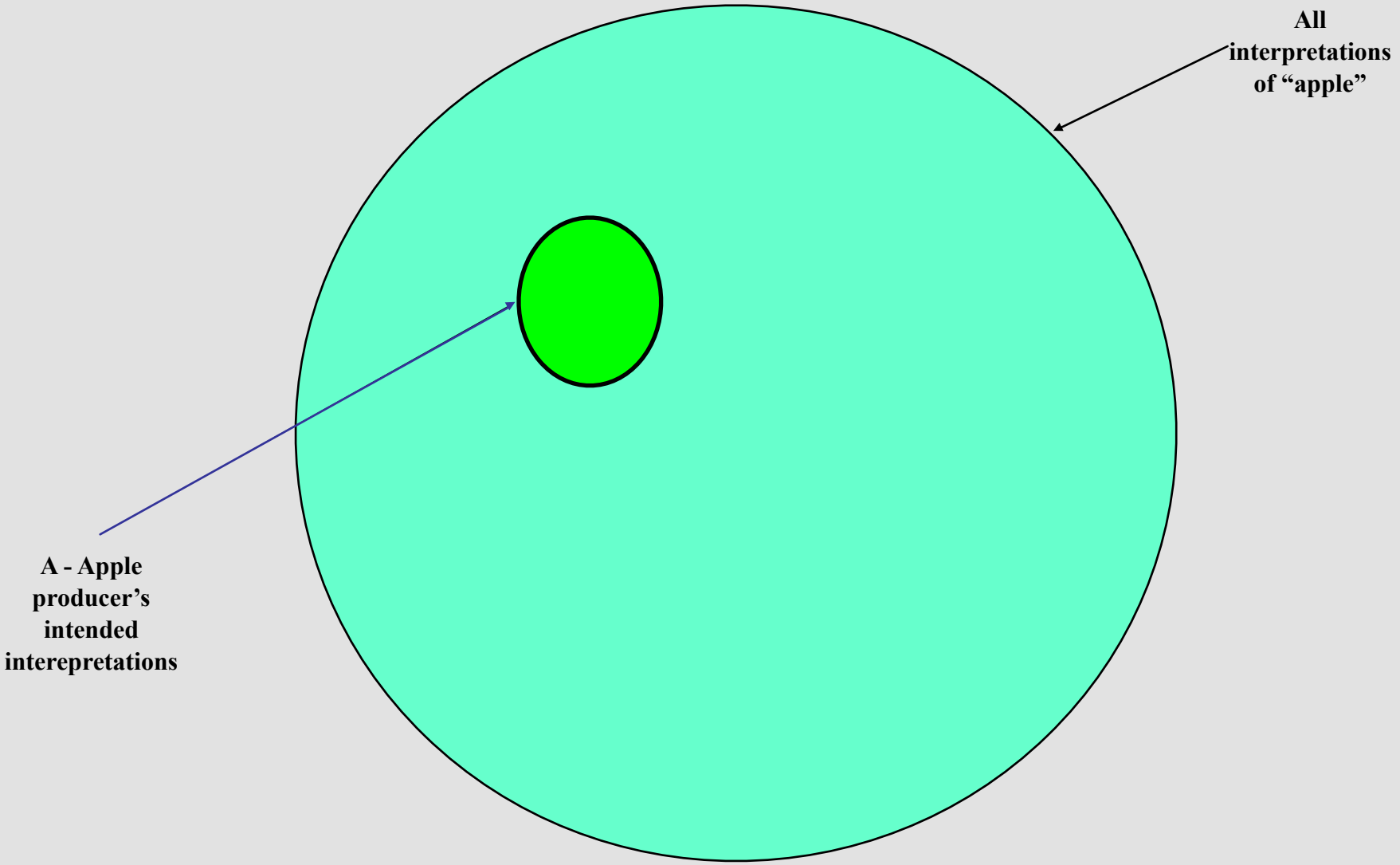
Database B: keeping track of juice stock

Variety	Quantity
Granny Smith	12
Golden delicious	10
Stark delicious	15

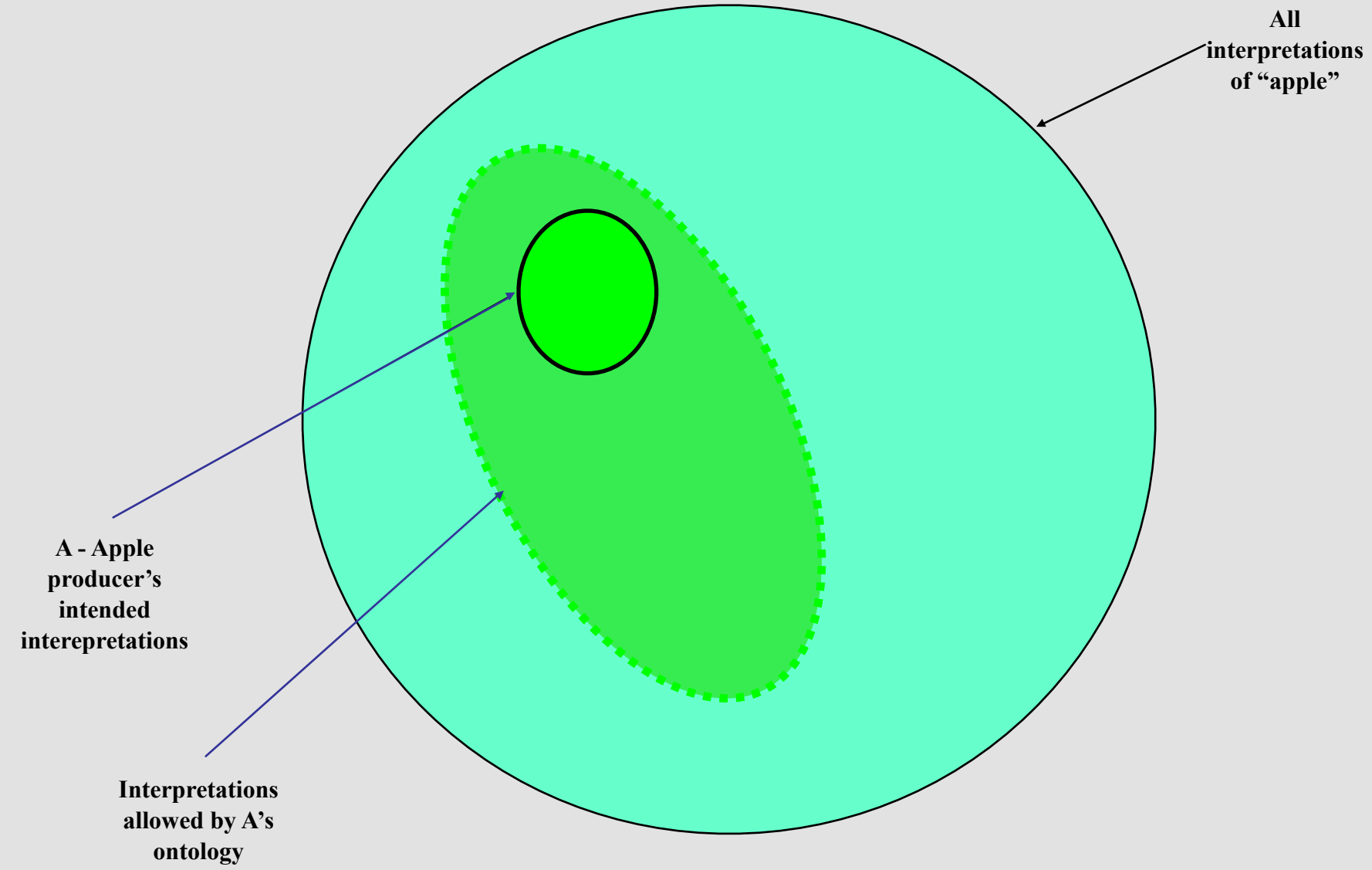
Why ontological precision is important



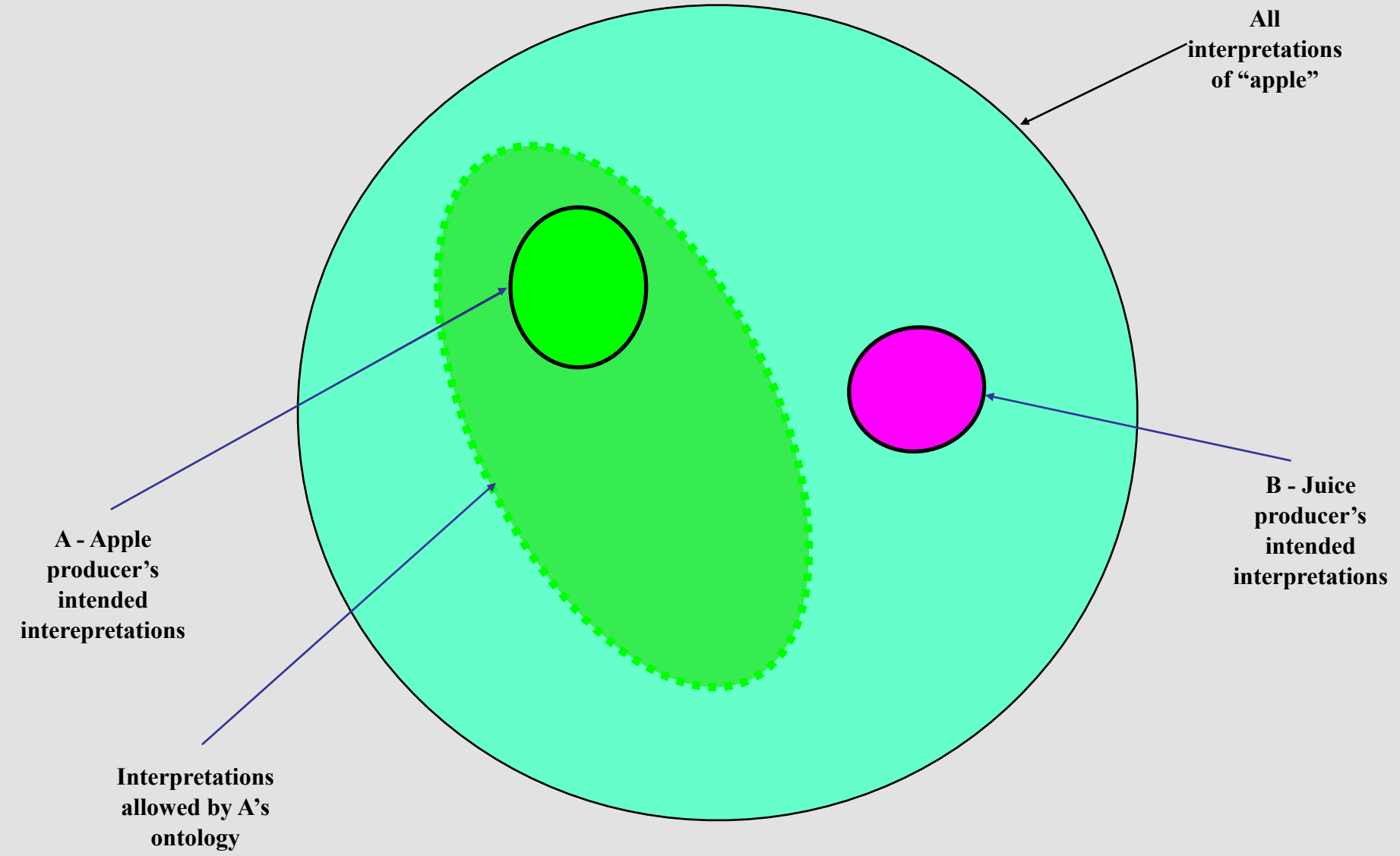
Why ontological precision is important



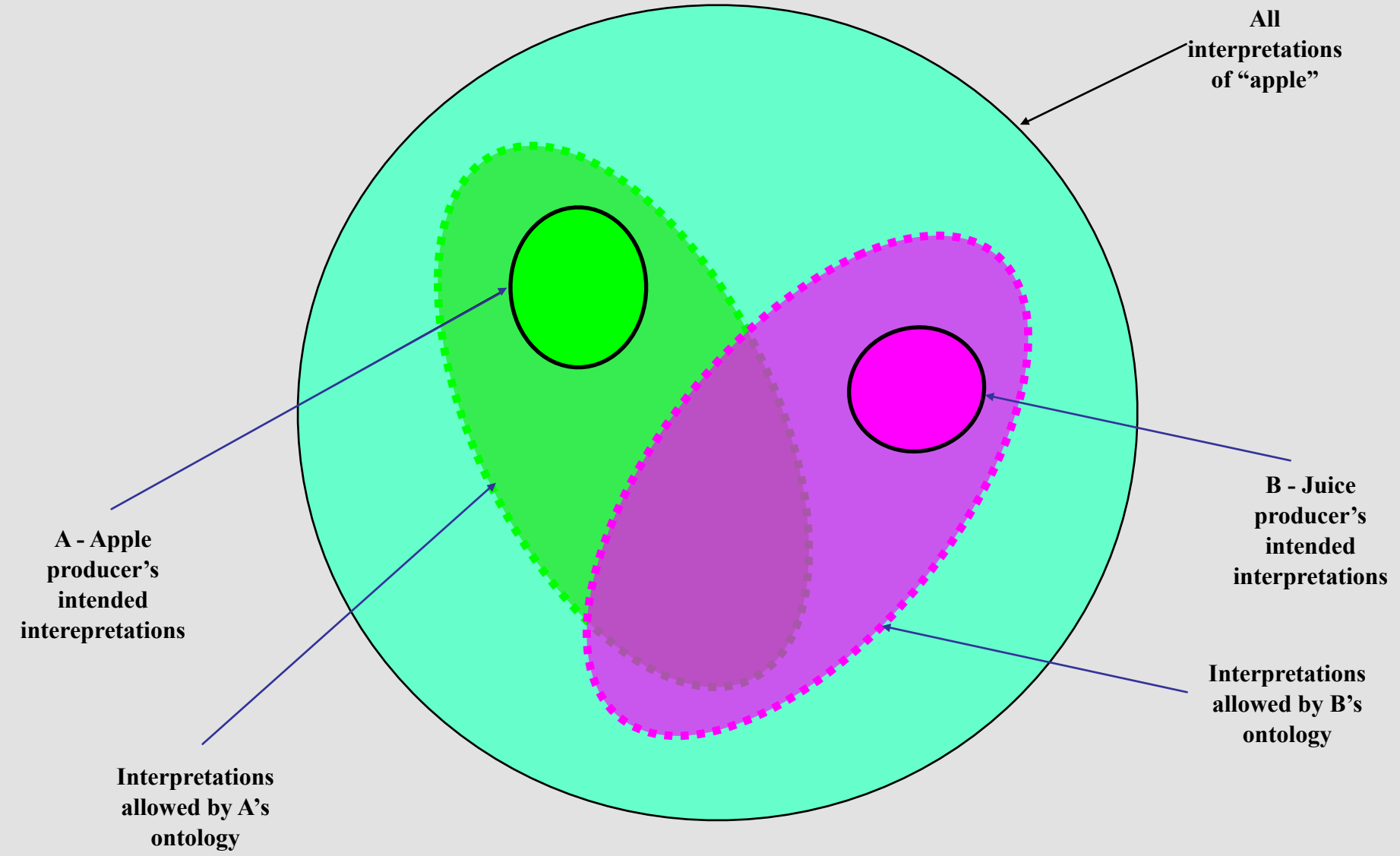
Why ontological precision is important



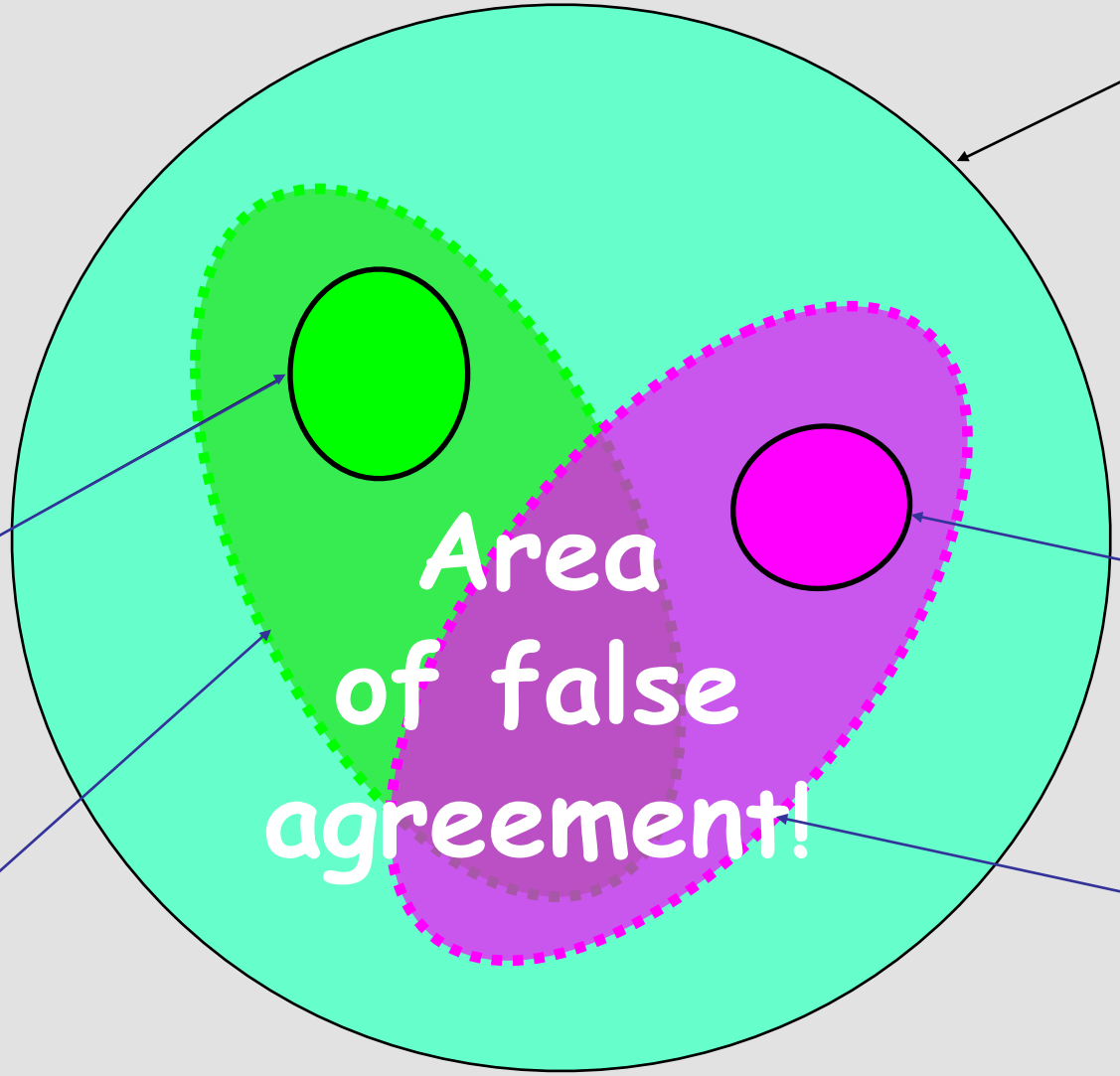
Why ontological precision is important



Why ontological precision is important



Why ontological precision is important



When is a precise (and accurate) ontology useful?

When is a precise (and accurate) ontology useful?

1. When *subtle distinctions* are important

When is a precise (and accurate) ontology useful?

1. When *subtle distinctions* are important
2. When *recognizing disagreement* is important

When is a precise (and accurate) ontology useful?

1. When *subtle distinctions* are important
2. When *recognizing disagreement* is important
3. When *careful explanation and justification* of ontological commitment is important

When is a precise (and accurate) ontology useful?

1. When *subtle distinctions* are important
2. When *recognizing disagreement* is important
3. When *careful explanation and justification* of ontological commitment is important
4. When ***mutual understanding*** is more important than interoperability.

The two fundamental scenarios for semantic integration

The two fundamental scenarios for semantic integration

1. *Same domain, same terminology, same conceptualization:* e.g, different processes within a very small, family-managed enterprise (everybody does everything)

The two fundamental scenarios for semantic integration

1. *Same domain, same terminology, same conceptualization:* e.g, different processes within a very small, family-managed enterprise (everybody does everything)

2. *Same domain*, *shared terminology*, *different conceptualization*: e.g., different branches of a big company with a strong organization structure..

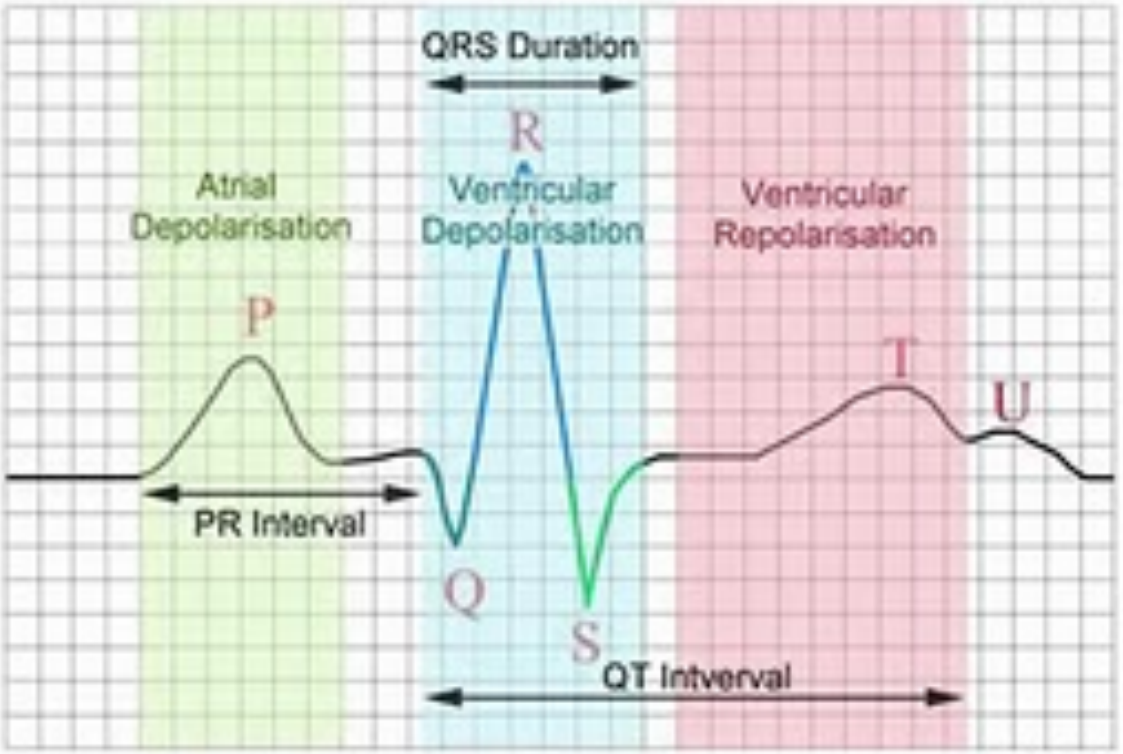
The two fundamental scenarios for semantic integration

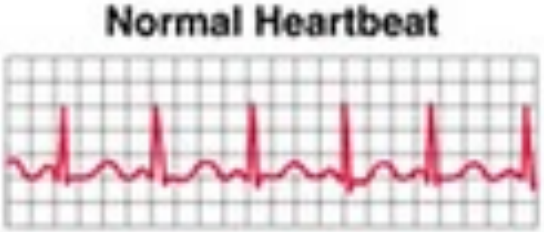
1. *Same domain, same terminology, same conceptualization:* e.g, different processes within a very small, family-managed enterprise (everybody does everything)

2. *Same domain*, *shared terminology*, *different conceptualization*: e.g., different branches of a big company with a strong organization structure..

Computational ontologies have been born for 2, but, they are actually used for 1: ***just shared*** *data schemes*. The result is the so-called "**data sylos**" **effect.**

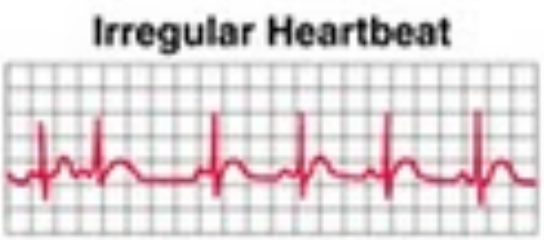
Ontologies and (big) data

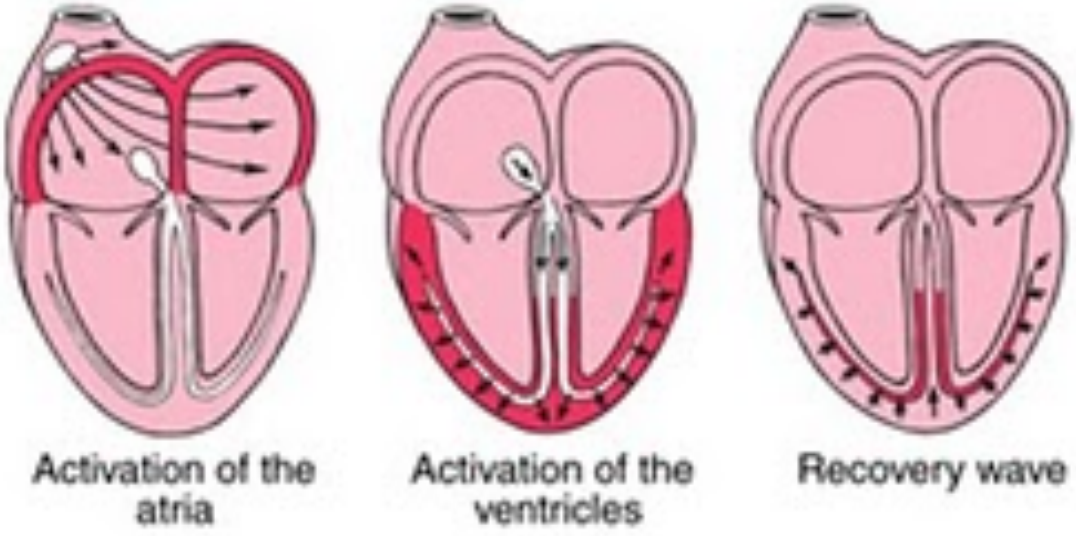

QRS Duration
R
Atrial Depolarisation
Ventricular Depolarisation
Ventricular Repolarisation
P
T
U
PR Interval
Q
S
QT Intverval


Normal Heartbeat


Fast Heartbeat


Slow Heartbeat


Irregular Heartbeat


Activation of the atria
Activation of the ventricles
Recovery wave

A single, imperialistic ontology?

A single, imperialistic ontology?

- An ontology is first of all ***for understanding each other***
  - ...among people, first of all!
  - not necessarily for thinking in the same way

A single, imperialistic ontology?

- An ontology is first of all ***for understanding each other***
  - ...among people, first of all!
  - not necessarily for thinking in the same way
- A single ontology for multiple applications ***is not necessary***
  - Different applications using different ontologies can co-exist and co-operate (not necessarily inter-operate)
  - ...if linked (and compared) together **by means of a general enough basic categories and relations (*primitives*)**.

A single, imperialistic ontology?

- An ontology is first of all ***for understanding each other***
  - ...among people, first of all!
  - not necessarily for thinking in the same way
- A single ontology for multiple applications ***is not necessary***
  - Different applications using different ontologies can co-exist and co-operate (not necessarily inter-operate)
  - ...if linked (and compared) together **by means of a general enough basic categories and relations (*primitives*)**.
- If basic assumptions are not made explicit, any imposed, common ontology risks to be
  - seriously mis-used or misunderstood
  - opaque with respect to other ontologies

The formal tools of ontological analysis

The formal tools of ontological analysis

The formal tools of ontological analysis

- Theory of Parts (Mereology)
- Theory of Unity and Plurality
- Theory of Essence and Identity
- Theory of Dependence
- Theory of Composition and Constitution
- Theory of Properties and Qualities

The formal tools of ontological analysis

- Theory of Parts (Mereology)
- Theory of Unity and Plurality
- Theory of Essence and Identity
- Theory of Dependence
- Theory of Composition and Constitution
- Theory of Properties and Qualities

The basis for a common ontology vocabulary

The formal tools of ontological analysis

- Theory of Parts (Mereology)
- Theory of Unity and Plurality
- Theory of Essence and Identity
- Theory of Dependence
- Theory of Composition and Constitution
- Theory of Properties and Qualities

The basis for a common ontology vocabulary

Idea of Chris Welty, IBM Watson Research Centre, while visiting our lab in 2000

Formal Ontology

Formal Ontology

- Theory of ***formal distinctions and connections*** within:
  - entities of the world, as we perceive it (***particulars***)
  - categories we use to talk about such entities (***universals***)

Formal Ontology

- Theory of ***formal distinctions and connections*** within:
  - entities of the world, as we perceive it (***particulars***)
  - categories we use to talk about such entities (***universals***)
- Why ***formal***?
  - Two meanings: ***rigorous*** and ***general***
  - Formal logic: connections between truths - neutral wrt ***truth***
  - Formal ontology: connections between things - neutral wrt ***reality***
- ***NOTE:*** **"represented in a formal language" is not enough for being formal in the above sense!**
- ***Analytic ontology*** may be a better term to avoid this confusion

An example of formal ontological distinction

An example of formal ontological distinction

- Is a bypass capacitor a ***kind*** of capacitor?

An example of formal ontological distinction

- Is a bypass capacitor a ***kind*** of capacitor?
- What's the difference between a bypass capacitor and a tantalum capacitor?

An example of formal ontological distinction

- Is a bypass capacitor a ***kind*** of capacitor?
- What's the difference between a bypass capacitor and a tantalum capacitor?
- What's the difference between ***kinds*** and ***roles***?

Current Research topics

Ontology of socio-technical systems

- Multi-agent systems, social interaction, and collective intentionality
- Ontology of organizations and social roles
- Ontology of functions, artefacts, and engineering design
- Integrated modelling of organizations, processes, and services
- Ontological foundations of service science and value-cocreation
- Visual recognition of crisis situations; role of emotions in crisis situations
- Role of crises and contradiction in social interaction

Ontology, language, cognition

- Ontology, cognition, and natural language semantics
- Ontology and lexical resources
- Formal semantics of discourse and dialogue relations
- Ontology and epistemology of measurement
- Perception of visual objects
- Perception, social conventions, and ontological constructivism

Principles and methodologies for ontological analysis, conceptual modeling, knowledge representation, and software engineering

- Formal ontological analysis: theories of properties, qualities, parts, unity, identity, dependence...
- Ontology-driven conceptual modelling

Methodology

IAOA

The International Association for Ontology and its Applications

News and Info

Join the IAOA **mailing list here**.
Download the **Association info flyer**.
Download the **Association statute**.
Please help us find a **logo**.

FOIS 2010
Sixth International Conference on Formal Ontology in Information Systems (CFP)

Welcome to the homepage of the IAOA. We will be extending this page over the coming weeks and month and welcome your input; meanwhile you will find all the necessary information to see what the association is for, what it might do for you, and how you can join.

Mission Statement:

The International Association for Ontology and its Applications is a non-profit organization the purpose of which is to promote interdisciplinary research and international collaboration at the intersection of philosophical ontology, linguistics, logic, cognitive science, and computer science, as well as in the applications of ontological analysis to conceptual modeling, knowledge engineering, knowledge management, information-systems development, library and information science, scientific research, and semantic technologies in general.
IAOA is open to all individuals and institutions who share its goals.

The Association is addressed to:

- Philosophers who have an interest in applying their analytical tools to technology advancement;
- cognitive scientists, linguists and terminologists aware of the subtle interplays among ontology, language, and cognition;
- computer scientists and IT professionals aware of the desperate need of a sound interdisciplinary approach for building future generation socio-technical systems.

The IAOA flagship journal: ***Applied Ontology***

Editors in chief:

Nicola Guarino
ISTC-CNR

Mark Musen
Stanford University

IOS Press

Amsterdam, Berlin, Washington, Tokyo, Beijing

www.applied-ontology.org

Now indexed by ISI and Scopus.
Impact Factor: 1.105

A new discipline (or science) is emerging?

A new discipline (or science) is emerging?

Maybe.

A new discipline (or science) is emerging?

Maybe.

See the history of Psychology, Systems Engineering...

A new discipline (or science) is emerging?

Maybe.

See the history of Psychology, Systems Engineering...

See recent proposals for Web Science, Services Science, **Data Science??**…

A new discipline (or science) is emerging?

Maybe.

See the history of Psychology, Systems Engineering...

See recent proposals for Web Science, Services Science, **Data Science??**…

For sure, a ***humble***, truly interdisciplinary approach is needed, focusing on letting new ideas, approaches, methodologies emerge from the ***mutual cross-fertilization*** of different disciplines.