

Objects, events, qualities

An introduction to formal ontological distinctions (in DOLCE)

Lecture 1

Claudio Masolo

Laboratory for Applied Ontology, ISTC-CNR

`masolo@loa-cnr.it`

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1 Description

- This course is intended to introduce the student to the formal distinctions among basic ontological categories, such as objects, events, and qualities. These categories will be characterized in an axiomatic way, using the analytic tools of so-called formal ontology, which builds on general notions such as parthood, dependence, identity, constitution. We shall discuss in particular the foundational choices behind the DOLCE ontology (<http://www.loa-cnr.it/DOLCE.html>), an axiomatic upper-level ontology being used for various purposes by a growing community of researchers, which has been designed to provide some ontological ground to common-sense natural language expressions.

2 Description

- Starting from classic puzzles related to basic ontological choices, such as those concerning spatial co-localization and temporal change, we shall discuss DOLCE's foundational choices in comparison with alternative philosophical options. As a conclusion, we shall also show possible ways to use the distinctions we presented as a basis for application ontologies easier to understand, integrate, and maintain.

3 Lectures

1 **Ontological and semantic puzzles.**

- ▶ content-reality-conceptualization-models
- ▶ realism vs. knowledge representation
- ▶ multiplicativism, rephrasing, onto commitment, to be in the domain of quantification, strong realism vs. constructivism (is it possible to have something in the middle?)
- ▶ representation language (FOL)
- ▶ reification and modal logics
- ▶ what is a foundational ontology
- ▶ ontology and KB + ontology and NL
- ▶ ontological, semantical, and representational puzzles
- ▶ the problem of primitives and axioms

- ▶ the idea of the library of ontologies
- ▶ history of DOLCE

2 **Properties, concepts, and qualities.**

- ▶ non temporary properties (postpone temp. prop. to persistence)
- ▶ universals, tropes, universals+tropes, resemblance nominalism
- ▶ essential properties and sortals
- ▶ reification mechanism
- ▶ quality spaces (spaces of properties)
- ▶ **tirare fuori gli es. con gancarlo per utilita' tropi in CM**

3 Persistence through time and change.

- ▶ ' a has P at t ' how can it be represented
- ▶ how change can be represented (trope substitution in the case of trope theory)
- ▶ example: ternary relations in DL
- ▶ roles (example: customers)
- ▶ definitions/descriptions and definitional dependence

4 Constitution and supervenience.

5 Objects vs. events.

- ▶ introduced for semantic: do we draw ontological conclusions? (p.xiv events)
- ▶ events: reification again (John saw Mary cry (events p.xiii))
- ▶ (different ways of) participation and thematic roles
- ▶ eventists' views: Quine, Lewis, Kim, Bennett, Lombard
- ▶ identity criteria for events: *quine*: same spatio-temporal location (excludes the rotating and heating sphere example); *Davidson* same place in the causal network, same causes/same effects

5 **Using basic ontological categories to build application ontologies.** (questo resta molto tra parentesi, perche' non so che cosa dire)

- I do not consider here:
 - ▶ actions and causation (reference to extension of DOLCE Laure and Robert)
 - ▶ deep linguistic arguments (I'm not a linguist)

4 Ontological analysis: from form to content

- The key problems
 - ▶ content-based information access (*semantic matching*)
 - ▶ content-based information integration (semantic integration)
- To approach them, content must be studied, understood, analyzed as such, independently of the way it is represented.
- Traditionally, computer technologies are not really good for that. . .
- ★ **Ontological analysis:** study of *content qua content* (independently of representation).
- **in realta' vado anche a vedere come lo studio ontologico puro poi interagisca con la rappresentazione, questo va detto!!**

5 Do we know what to represent?

- First ontological analysis, *then* knowledge representation.
 - Unfortunately, this is not the current practice.
 - **how to represent (approximate) the ontological analysis assuming the constraints of a given representation language**
- ★ No ontology without ontological analysis!

6 The need to focus on content

FORSE NON SERVE

- Philosophers have generally stopped short of trying to actually specify the truth conditions of the basic atomic propositions, dealing mainly with the specification of the meaning of complex expressions in terms of the meanings of elementary ones. Researchers in artificial intelligence are faced with the need to specify the semantics of elementary propositions as well as complex ones. [Woods 1975]
- The majority of work in knowledge representation has been concerned with the technicalities of relating predicate calculus to other formalisms (...). There has been almost an aversion to addressing the problems that arise in actually representing large bodies of knowledge with content. The typical AI researcher seems to consider that task to be just applications work. But there are deep,

important issues that must be addressed (...): What ontological categories would make up an adequate set for carving up the universe? How are they related? What are the important things most humans today know solid objects? And so on. In short, we must bite the bullet [Doug Lenat]

7 Ontology and semantics

- Strictly intertwined: ontology is about *what there is*, semantics is about *referring* to what there is.
- Structural semantics vs. referential semantics.
 - ▶ Referential semantics requires a representation of the world.
 - ▶ Choice of a descriptive attitude: language-dependent world for being faithful to linguistic behaviour and or a cognitive conceptualization of reality.
 - ▶ Analyzing the ontological commitment of NL, i.e., doing “natural-language metaphysics” [Bach, 1986b]

8 Ontologies

- **O**ntology vs. Ontology vs. **o**ntology
- Trend: **O**ntology \sim realism; **o**ntology \sim taxonomy (or, in any case, the model domain experts produce from scratch without taking into account possible alternatives and without founding it)
- Here I will defend a intermediate position, Ontology: take what **O**ntologists do in a more multiplicativist/constructivist light and apply it to avoid ad-hoc and not well founded **o**ntologies.
- **chiaramente da sistemare, ma va detto,
le prossime slides elaborano un po', forse metterle prima**

9 Il problema delle primitive

Entra in scena l'ontologia *formale* e l'*analisi ontologica*:

- L'idea fondamentale consiste nello sfruttare il lavoro fatto in *logica*, *filosofia*, *linguistica*, *scienze cognitive*, ecc. per individuare un insieme di primitive concettuali **generali** che possano essere applicate in svariati domini e che servano da base per lo sviluppo di modelli più specifici e consentano di avere diversi livelli di dettaglio della descrizione.

⇒ approccio intrinsecamente *multidisciplinare*

⇒ secondo senso di formale: *generale*, indipendente da specifici domini di applicazione (Husserl)

10 Nuova attitudine richiesta

- *Logica*. Da **L**ogica a **l**ogiche.

Non è interessante considerare soltanto LA teoria della “verità”, ma diverse teorie della verità e diversi tipi di ragionamento hanno senso in **contesti** diversi.

- *Filosofia*. Da **O**ntologia a **o**ntologie.

Non è interessante considerare soltanto LA teoria delle entità e la struttura della “realtà” ma diverse teorie ontologiche rendono conto di aspetti diversi: linguistici, di senso comune, ecc.

- *KR*. Da modelli arbitrari a ontologie.

Nello sviluppo di una base di dati, di una base di conoscenza, in generale di un modello, deve essere riconosciuta l'importanza dell'*analisi ontologica* e quindi degli strumenti concettuali per la rappresentazione.

11 Verso una libreria di ontologie

- NO approccio monolitico, NO unica ontologia standard (questa è una delle critiche più ricorrenti all'ontologia formale)
- Piuttosto, un (piccolo) insieme **integrato** di ontologie generali (*ontologie fondazionali*) che riflettano *posizioni* ed *impegni* ontologici diversi.
- Buona documentazione delle opzioni base e delle loro interdipendenze

12 Utilità della libreria

- Strumento iniziale per lo sviluppo di nuove ontologie sia fondazionali che di dominio
⇒ verso una metodologia per l'analisi ontologica
- Strumento di riferimento per un confronto rigoroso di approcci ontologici diversi
⇒ verso l'integrazione ontologica
- Ambiente comune per l'analisi e l'armonizzazione di ontologie e "metadata standards" già esistenti
⇒ verso la *fiducia* nelle applicazioni

13 Different ontological commitments/choices

At the foundational level:

- no single/monolithic foundational ontology.
- Rather, a (small) set of foundational ontologies carefully justified and positioned with respect to the space of possible choices.
- Basic options clearly documented.
- Clear branching points to allow for easy comparison of ontological options).

The same can be do in the case of *core* and *domain* ontologies, even though the disagreement is usually higher at the foundational level.

14 Summing up

(1/2)

We have seen that:

- there exists a *space* of orders and mereologies, i.e. that the multitude of orders and mereologies that can be organized according to some formal and practical dimensions
⇒ *library of theories*; and
- orders and mereologies have been *reused* in the theories of time
⇒ library of *theories* \approx library of *routines*
⇒ *modularization* and incremental development of theories.

but...

15 Summing up

(2/2)

For example, theories of time disagree on:

- **domain:** instants vs. periods (there are also theories that consider both instants and periods, or events)
- **primitives:** even theories that agree on the domain can disagree on primitives (an example in the theory of time: precedence+parthood vs. meets)
- **axioms:** there are a huge space of possible characterizations of the primitives that identify different structures.

How is it possible to integrate systems based on different theories or at least to allow for their interoperability?

16 Mappings

- In order to formally compare different ontologies (more specifically different modules) we need to try to find some *translation* from a module to another one.
- **Syntactic mappings.** Axioms+FOL links are particularly useful for comparing theories that agree on the domain but disagree on primitives/axioms.
- **Semantic mappings.** Not so useful for comparing theories that disagree on the domain (instants vs. periods vs. events) because often the links between the domains require more expressive power. In this case we need to consider set-theoretical mappings between structures that are models of the theories.
- Here we will see two simple examples of syntactic mappings.

17 Library of ontologies

- Reflects different commitments and purposes, rather than a single monolithic view.
- Is a starting point for building new foundational or specific ontologies.
- Is a reference point for easy and rigorous comparison among different ontological choices.
- Furnishes a common framework for analyzing, harmonizing and integrating existing ontologies and metadata standards.

18 Structure of the library

The modules can be organized along two dimensions:

- **visions**, corresponding to basic ontological choices made;
- **specificity**, corresponding to the levels of generality/specific domains.

19 Libraries of theories again

- The space of mereologies is an important *conceptual* tool because it 'encapsulates a deep analysis of different notions that are intuitively linked to the general notion of parthood (idea of the ontological module).
- Different theories can be *adequate* to specific modeling requirements: the user selects the theory that better matches his needs.
- No monolithic/standardized approach: the links between the theories in the library make explicit their (in)compatibilities.
- We have seen as the orders has been re-used for mereologies, we will see how different mereologies can be *reused* for modeling more specific domains: time, space, physical objects, qualities, organizations, etc.

20 Why formal ontology?

- Provide a carefully crafted taxonomic backbone to be used for domain ontologies.
- Help recognizing and understanding disagreements as well as agreements.
- Improve ontology development methodology.
- Provide a principled mechanism for the semantic integration and harmonisation of existing ontologies and metadata standards.
- Improve the trust on web services.

21 From a methodological point of view

We will see how formal ontology can help in

- the **reuse** of theories in different contexts and domains;
- a **modular** approach to ontology building;
- the **comparison** between different theories that correspond to alternative ontological positions;
- the **separation** between the conceptual/ontological analysis and the implementation under specific applicative constraints.

22 Ontology-driven conceptual modeling

- Chiarire la semantica dei linguaggi di modellazione concettuale (es. UML) e introdurre una metodologia di sviluppo
- Aggiungere delle primitive concettuali ontologicamente fondate che aumentino l'espressività ontologica
- Introdurre dei “design-patterns” che assicurino soluzioni compatte e ben fondate a problemi ricorrenti nella modellazione
- Esempi:
 - Metodologia Ontoclean (<http://www.ontoclean.org/>)
 - Agent-oriented security mod. (<http://www.loa-cnr.it/mostro>)
 - Design patterns (codificati come UML profiles) per rappresentare: *ruoli, qualità, descrizioni*, ecc. (Guizzardi e Gangemi)

23 Integrazione ad accesso semantici

Problema: dati due agenti (basi di dati, applicazioni web) con differenti ontologie, come faccio a farli a comunicare tra di loro in modo corretto?

- La formalizzazione dell'impegno ontologico sembra necessaria per la possibilità di un'integrazione (semi)automatica
- Una soluzione seguita in pratica è l'uso di un'*interlingua*, cioè mapping ad un'ontologia comune
- La libreria di ontologie moltiplica questa possibilità svincolandosi da una particolare ontologia comune
- Si veda il D18 del progetto europeo IST-WonderWeb per più dettagli su questo punto (<http://wonderweb.semanticweb.org/>)

24 Ontologie e Linguaggi Naturali (1)

Problema 1: *allineamento* tra ontologie formali e lessici (computazionali), quali ad es. WordNet, che consente:

- di rendere più rigoroso e cognitivamente trasparente WordNet
- di fondare linguisticamente l'ontologia
- l'uso dell'informazione contenuta nell'ontologia per il NLP
- l'uso dell'informazione linguistica per arricchimento ontologie

Esempio:

- OntoWordNet: allineamento di DOLCE con WordNet + apprendimento e revisione da corpora e glosses (Oltramari e Gangemi) (<http://www.loa-cnr.it/DOLCE.html#OntoWordNet>)

25 Ontologie e Linguaggi Naturali (2)

Problema 2:

- Qual'è il legame tra ontologia e semantica formale dei NL?
- Qual'è l'impegno ontologico dei NL?

Non una vera applicazione ma molto importante per una visione *composizionalista* del linguaggio, che potrà risultare fondamentale in future applicazioni

Persona di riferimento: Laure Vieu

26 Philosophical ontologies

- In philosophy, the ontology is the study of what there is (*being qua being...*).
- Study of the nature and structure of “reality”.
- A (philosophical) ontology: a structured system of entities assumed to exist, organized in categories and relations.
- A liberal reinterpretation for computer science: *content qua content*, independently of the way it is represented

27 Representation and reasoning

- Representation comes first!
- The very task of representation (i.e. modelling) is left to the user.
- AI researchers focus more on the nature of reasoning than in the nature of the real world.
- ★ **Essential ontological promiscuity of AI:** any agent creates its own ontology based on its usefulness for the task at hand (Genesereth and Nilsson 1987)

...just talking of whatever we like?

28 Computational ontologies

- Specic (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 specications 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.
- Focus on:
 - ▶ Meaning of terms.
 - ▶ Nature and structure of a domain.

29 Working definition in this course

- A FOL theory intended to semantically characterize the primitive predicates by ruling out as much as possible non-intended models

30 Espressività logica

Si possono scegliere diversi linguaggi logici per la caratterizzazione delle primitive:

- logiche del secondo ordine
- logiche del primo ordine
- logiche del primo ordine modali
- logiche descrittive (es. OWL)
- tassonomie (usate per le “lightweight ontologies”)
- ...

Nota. Alcuni linguaggi di modellazione concettuale non hanno ancora una chiara semantica, come ad es. UML.

31 The problem of the language

(1/2)

- In which formal language the modules need to be written?
- If we start from an expressive language allowing for good characterization of primitives, we have the problem of *approximate* the theory in a language less expressive with better computational behavior.
- For example we could use FOL as development language and OWL as implementation language.
- Approximations are dependent on external knowledge and requirements, and therefore it is very difficult to have automatic translations (from FOL to OWL for example).

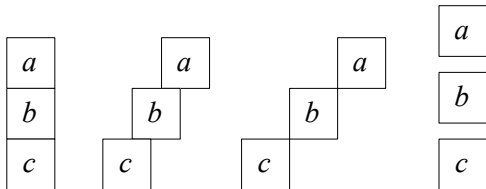
32 The problem of the language

(2/2)

- If we start with a very poor language, then we often cannot characterize in a good way the primitive notions.
- We are quite far from the syntax abstraction achieved in software engineering. Often the theories in the ontologies are designed to solve specific expressive limitations: the n -ary properties in OWL.

33 Espressività ontologica

Fissato il linguaggio logico (FOL), e usando soltanto le primitive B e \triangleright , si possono distinguere le seguenti situazioni?



Quali primitive (concettuali) sono necessarie per il modello di cui si necessita?

34 Espressività (logica-ontologica) e applicazioni

- maggiore espressività → maggiore precisione e accuratezza (nella caratterizzazione delle primitive)
- maggiore espressività → peggiore comportamento computazionale

Problema aperto. È possibile avere un *ambiente di sviluppo* di ontologie molto espressivo e:

- *ritagliare* la parte dell'ontologia che mi interessa per una specifica applicazione, e
- *tradurla* (almeno in modo parziale) verso linguaggi meno espressivi a seconda dei vincoli espressivi e computazionali dettati dall'applicazione stessa?

35 Formal ontology, foundational ontology, logic

- 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)
- Two meanings of formal: *rigorous* and *general*
 - ▶ **Formal logic**: connections between *truths* - neutral wrt truth.
 - ▶ **Formal ontology**: connections between *things* - neutral wrt reality. – **in che senso neutrale rispetto alla realtà?**
 - ▶ Le logiche si occupano della nozione di verità, della nozione di deduzione e dei connettivi tra proposizioni.
 - ▶ Le ontologie si occupano dei tipi e delle relazioni tra le entità del dominio.
- Foundational ontologies.... **prendere qualche cosa da hand-dolce**

36 Ontologies and logics

Logica ed ontologia sono due mondi separati?

- la logica potrebbe essere vista come parte dell'ontologia da un punto di vista prettamente teorico
- esistono delle logiche modali che, secondo me, coinvolgono entrambi gli aspetti:
 - ▶ logiche epistemiche (credenze, desideri, intenzioni, ...)
 - ▶ logiche temporali e spaziali
 - ▶ logiche deontiche (diritti, obbligazioni, permessi, ...)
 - ▶ logiche dinamiche e delle azioni

37 Ontological and semantic puzzles

- Two different interpretations of parsimony: the price of Hogan must pay for the elimination of events is the proliferation of logical connectives – special, non-truthfunctional connectives [or relations/predicates]; the price eventists must pay is the proliferation of entities in the domain – whence an increase in the number of categories. (events, p.xxi)
- **qui parlare del discorso logica modale vs. reificazioni, quindi operatori vs. avere qualche cosa nel dominio**

38 The traps of revisionism

- Is systematic paraphrasing really possible (also for complex sentences)?
 - ▶ There are 7 holes in this piece of cheese.
- How to choose whether paraphrasing?
 - ▶ Mary makes a leap.
 - ▶ Mary makes a cake.
- Can we account for proper inferences?
 - ▶ There are two things John gave to Mary: a kiss and a flower.
- Where to stop while eliminating entities?
 - ▶ Should we paraphrase everything in terms of bunches of molecules moving around?

39 The rich ontology of natural language

- Multiple co-located events
 - ▶ John sings while taking a shower.
- Multiple co-located objects
 - ▶ I am talking here
 - ▶ *This bunch of molecules is talking
 - ▶ * What's here now is talking

 - ▶ This statue is looking at me
 - ▶ *This piece of marble is looking at me
 - ▶ This statue has a strange nose
 - ▶ *This piece of marble has a strange nose

- Individual qualities

- ▶ The nurse measured the patient's temperature
- ▶ I like the color of this rose
- ▶ The color of this rose turned from red to brown in one week

40 Reductionism, expressivity, ontological relativity

- To express the reduction of a kind of entities to another kind of entities one often needs a expressive language, e.g. to reduce regions to points, set-theory is necessary.
- But points can be reduced to regions, buy using filters (**qui introdurrei proprio la costruzione formale**), therefore, in this case what are the most basic entities? (in this case the expressivity is still higher)
- Quine's ontological relativity and the absence of empirical facts that tell us if regions or points are the most basic entities **vedi anche la nostra intro su articolo mereogeom**

41 Spatial coincidence

A sculptor creates the statue of the infant Goliath by sculpting the lump of clay Lumpl.

- Lumpl, but not Goliath, would survive a squeezing while Goliath, but not Lumpl, would survive the loss of some parts.
- Goliath, by a continuous and complete renovation of the clay it is made of, could survive the destruction of all parts of Lumpl.
- Lumpl already existed before the sculptor bought it, while Goliath comes into existence only once the sculptor has completed her work.
- Goliath, but not Lumpl, has been created by an artist, it costs 2000 euros, it causes you to pay a ticket to see it.

42 Counting problem

In 2009, Alitalia carried a million passengers. If, in 2009, some persons flew Alitalia more than once then Alitalia served less than a million persons (similarly for roles in general).

- To count the passengers of an airline one cannot simply count the persons that flew it.
- Passengers but not persons have a flight number and specific rights and obligations.
- A person can fly different airlines or she can fly several times the same airline with different destinations or simply in different days.

43 Conflict properties paradox

Luc as passenger of Air France has the right of checking in online, while, as passenger of Alitalia, has the obligation of checking in at the airport.

- If passengers reduce to persons then one obtains a contradiction: Luc cannot have both the right of checking in online and the obligation of checking in at the airport (assuming a standard view on rights and obligations).

44 Abstraction hierarchies

- *Abstraction hierarchies* can be used to represent a complex systems at different levels of detail.
- High-level objects can be seen as the result of an abstraction process that starts from basic (often physical) objects.
 - ▶ Cells can be aggregated to compose organs with specific functions, i.e. cells are the 'physical implementations' of organs. (the same for the components of a complex system)
 - ▶ Relation between an one object and a *plurality* of objects.
- To plan a trip a road can be seen as a 2D object that abstracts from its 3D aspects.
 - ▶ Relation between two objects without spatial coincidence.

45 Some ontological choices

Universals, Particulars and Individual Properties

- Properties are universals (repeatables), e.g. redness, that apply to different entities OR properties are tropes (non-repeatables), i.e. individual properties inhering only in a specific entity, e.g. the red of this particular rose?
- Are entities the substrates of their properties or are they the aggregations of their properties?

46 Some ontological choices

Persistence of entities

- How do entities persist? What does it mean for an entity to change maintaining its identity? Are entities spatio-temporal worms that change because they present different phases OR are they three-dimensional extended entities changing because they instantiate different properties at different times?
- Is it possible to have at the same time the two kinds of entity connected by a participation relation (events/processes vs. objects)?

47 Some ontological choices

Space and Time

- Are space, time and space-time absolute (i.e. regions of space, time and space-time are assumed in the ontology) OR are they relative (i.e. we can consider only spatial, temporal and spatio-temporal relations between entities)?
- Is space-time Newtonian, Galilean, . . . ?
- Is time and space based on extended entities (intervals of time, regions of space) or on punctual entities?

48 Some ontological choices

Localization

- Are all the entities localized in space (concrete) OR there exist entities that are not in space (abstract)?
- Is it possible to have different entities that are (spatially or spatio-temporally) co-localized?

49 Modelling strategies in Formal Ontology

- Context: expanding an existing foundational ontology
- Question1: what modelling choices are available when analyzing a new notion?
 - ▶ Are we talking of *something* new or not?
 - introduce new individuals (of a new category)
 - introduce a new property of existing individuals
 - ▶ If a property is enough, which theory of properties to use, and which formal account?
 - standard predicative approach
 - universals: new individuals + new relations
 - tropes: new individuals + new relation

- Question2: How to decide which is the most appropriate?

50 Decision is not so obvious

- Two cases considered here: *artefacts* and *roles*
- Do *the paperweight on my desk* and *this pebble* refer to the same individual?
 - ▶ If yes, “being a paperweight” (“being an artefact”) is a property instantiated by the pebble individual
 - ▶ If not, what makes the difference?
- Does *the Chancellor of Germany* refer to Angela Merkel?
 - ▶ If yes, what sort of property is “being a Chancellor”?
 - ▶ But isn’t any difference between Angela Merkel and *Angela Merkel as Chancellor*?

51 Principles

- Two entities are distinct if they have different *identity criteria*
 - But *parsimony* should control the proliferation of entities
-
- ▶ Tension between “unifiers” and “multipliers”, between applying Okham’s razor and accounting for subtle phenomena
 - ▶ Resolved in a variety of ways by different philosophers
 - ▶ Here, moderate multiplicative approach

52 A solution: multiplicativism

- Lumpl *constitutes*, but it is different from, Goliath.
 - ▶ Constitution is a factive (asymmetric) relation that does not reduce to parthood or co-location; it just allows the *inheritance* of some properties, i.e. it provides a sort of *unity*.
- Luc-qua-passenger *inheres in*, but he is different from, Luc.
 - ▶ During its whole existence, a qua-entity inheres in the same *host* (the player of the role passenger in the example).
- My heart is an *aggregation* of, but it is different from, a plurality of cells.

53 A note on multiplicativism and existence

- Does Goliath *really* exist or it is the result of a *conceptual* construction that collects different amounts of clay on the basis of cognitive criteria that can be founded on shape, continuity, etc.?
- In philosophy the *ontological/conceptual* distinction is fundamental.
- On one hand, KR can avoid to commit to reductionism or anti-reductionism: if multiplicativism solves problems, independently of the nature of the entities introduced, it deserves attention.
- On the other hand, the general (and foundational) point of view of philosophers is a very important input to avoid ad-hoc solutions that are difficult to generalize, re-use, and share.
- ▶ I'm particularly interested in this second aspect.

54 Focus

- Focus on two *multiplicative strategies*, that introduce new entities
 - ▶ for different identity criteria:
entity stacking
 - ▶ for a non predicative account of properties:
property reification

55 Entity Stacking

56 Identity criteria

- Most general identity criteria, *Leibniz's law*:
entities are identical iff they display the same properties
- No always very practical...
- Often restricted to *Mereological extensionality*:
entities are identical iff they have the same proper parts
- Further reduction: conflate parthood and spatial inclusion
so spatial co-location implies identity
“no two things at the same place at the same time”
- But a famous puzzle stems from this position:
the statue and the clay / Lump and Goliath

57 Entity stacking: co-location & dependence

- The amount of clay can be reshaped, the statue cannot
The statue can lose tiny parts, the amount of clay cannot
- Leibniz's law → co-location doesn't imply identity
- Instead, asymmetric relation of dependence between the statue and the clay: here *constitution*
- Co-location and dependence give rise to “stacks” of entities of different categories
 - ▶ For instance, in DOLCE:
Amounts of matter – Physical objects – Intentional agents

58 Entity stacking

- I will refine a multiplicative approach called *entity stacking* that is based on the notion of *existential dependence*:
 - ▶ Goliath depends on Lump1,
 - ▶ Luc-qua-passenger depends on Luc,
 - ▶ my heart depends on the on cells,but the opposite holds for none of the previous examples.
- This dependence can be generalized to kinds.
 - ▶ E.g. statues, to exist, require amounts of matter but amounts of matter can exist without any statue.

59 The case of physical artefacts

- Are artefacts just physical objects having the property of being manufactured ?
 - ▶ sawdust and cut-off nails are not artefacts
 - ▶ pebble-paperweights and shell-money are artefacts
- What counts is the function attributed by the artefact's creator
Could that be a property of a physical object?
 - ▶ The pebble is not meant to hold papers, the paperweight is
 - ▶ The pebble doesn't depend on some creator, the paperweight does
 - ▶ Your car maintains its identity through repairs or additions, the particular physical object doesn't
- Attributed function is an *essential* property of artefacts

60 The artefactual layer

- Further stacking, new entities:
artefacts *are constituted by* physical objects
- The statue and the clay revisited
 - ▶ the amount of clay
 - ▶ the physical object with a particular structure and shape
 - ▶ the statue created by an agent for a specific purpose
- The ship of Theseus revisited
 - ▶ the amount of wood
 - ▶ the physical object, ie, the particular assembly of planks
 - ▶ the ship created by an agent for a specific purpose

61 Property Reification

62 When predicates are inadequate

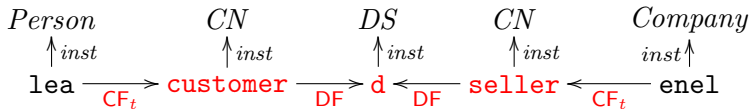
- Some universalists
 - ▶ Refuse extensionality: a property is not a set/class of entities
 - ▶ Refuse Boolean closure: any logical combination of properties doesn't make a property
- For conceptualists / ontologists of social reality
 - ▶ Concepts are created, can disappear, depend on societies or groups of agents that use them: *properties of properties*
- In both cases, to stay in FOL we need to:
 - ▶ *Reify* properties, ie, introduce new entities either *Universals* or *Concepts*
 - ▶ Introduce new relations of *instantiation*

63 The case of relational roles

- Roles, e.g., *customer*, *chancellor* or *catalyzer*, are treated as properties, most often unary predicates
- Characteristic, well-studied, aspects of relational roles:
dynamic, *anti-rigid* and *relationally dependent*
- Can be accommodated as defined binary predicates in FOL:
$$\text{Customer}(x, t) \triangleq \text{Person}(x) \wedge \exists y(\text{Company}(y) \wedge \text{Buys_from}(x, y, t))$$
- But two other aspects cannot
 - ▶ Roles are *intensional*: any equivalent formula cannot do, being so defined is an essential property of them
 - ▶ Roles are *conventional*: roles are concepts (created by a society and) depending on a defining convention

64 Reification of roles

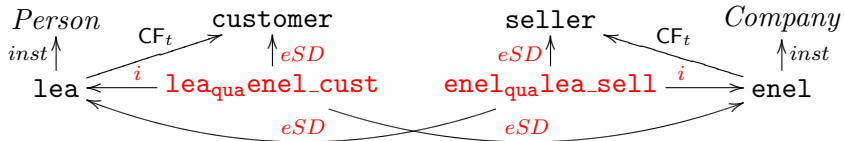
- Reification of roles
- Reification of their definitions
- Introduction of a “classified by” relation
- Introduction of a “defined by” relation



65 Qua-individuals: Entity stacking again

- Different properties for Lea and *Lea as customer of Enel*
- Different properties for simultaneous roles played by Lea:
Lea as customer of Telecom, Lea as customer of Enel
 - ▶ customer code, amount of money spent, ...
Not attributes of the property customer
- The counting problem: counting customers (passengers, representatives...) is not counting people (nor events, nor slices)
- What we count are “qua-entities”:
Lea-qua-Enel-customer, Lea-qua-AF1234-passenger
- Qua-entities *inhere* in the role players
Inherence is an *existential specific constant* dependence

66 Roles and qua-entities



67 Qua-individuals vs. tropes

- prendere qualche cosa da **AAAI05**

68 Discussion

- Multiplying entities → stronger ontological commitment
Unifying seems more cautious, more attractive
- Modelling perspective, requiring high expressive power
 - ▶ Integration of different ontological positions, even controversial ones
 - ▶ Reductionism may be very impractical, especially for entities of social reality (Heil)
- Entity stacking: pay attention to *identity criteria* and study the dependence relations of *constitution* and *inherence*
- Property reification: study *instantiation* relations, and be careful with the amount of “logic” imported at the object level

69 Conclusion

- Yet a third multiplicative strategy!
individual properties or tropes (cf. DOLCE)
- Put in the agenda of applied ontology the “manual of ontology modelling”
How to recognize which modelling strategy to apply when
- The next step after OntoClean?

70 Modal Logic vs. Ontology?

- Belnap et al., 2001:

“The modal logic of agency is not popular. Perhaps largely due to the influence of Davidson, but based also on very different work of such as Goldman’s and Thomson’s, the dominant logical template takes an agent as a wart on the skin of an action, and takes an action as a kind of event. This ‘actions as events’ picture is all ontology, not modality, and indeed, in the case of Davidson, is driven by the sort of commitment to first order logic that counts modalities as Bad.”

Each modal logic of agency, as STIT, “has the advantage that it permits us to *postpone attempting to fashion an ontological theory*, while still advancing our grasp of some important features of action...” .

71 Modal Logic vs. Ontology?

- No reason for considering the modal logic and the FO theory approaches as competing.
- No reason for not studying action and agency together.
- As any logical framework, STIT:
 - ▶ does carry ontological assumptions - mostly hidden in properties of its models;
 - ▶ can therefore be seen as an ontology of agency.
- If we want to focus on ontology issues, before dealing with reasoning, it is nevertheless easier and clearer to do it in a FOL framework.

72 Modal Logic vs. Ontology?

- **aggiungere qualche cosa sul rapporto FOL e logica modale, in cui si fa vedere come da una parte c'è una moltiplicazione di entità mentre dall'altra una moltiplicazione di operatori**

73 Standards and monolithic approaches

- An ontology is not for understanding each other BUT not necessarily for thinking in the same way.
- A standard ontology is not necessary: applications based on different ontologies can co-exist and cooperate (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

74 Space of Ontological Choices

da sistemare ma bisogna dire qualche cosa su questo

- Which structure: which *domain*, which *relations*, which *axioms*?
- Plenty of these issues need to be addressed when building a formal ontology.
- For instance, beside talking about location, we havent discussed much the fundamental notions of space and time.
 - ▶ Are space, time and space-time absolute or are they relative (i.e. the result of relations holding between entities)?
 - ▶ Are they atomic or atomless?
 - ▶ Which geometry do they satisfy?

75 Different ways of representing properties in FOL

- $\text{Red}(x) \wedge \text{Orange}(y) \rightarrow x \sim_{\text{C}} y$
- $\text{Color}(x, \text{red}) \wedge \text{Color}(y, \text{orange}) \wedge \text{red} \sim \text{orange}$
 - ▶ $\text{Red}(x) \triangleq \text{Color}(x, \text{red})$
 - ▶ $x \sim_{\text{C}} y \triangleq \exists c_1 c_2 (\text{Color}(x, c_1) \wedge \text{Color}(y, c_2) \wedge c_1 \sim c_2)$
- $\text{Inst}(x, \text{red}) \wedge \text{Color}(\text{red}) \wedge \text{Inst}(x, \text{orange}) \wedge \text{Color}(\text{orange}) \wedge \text{red} \sim \text{orange}$
 - ▶ $\text{Color}(x, \text{red}) \triangleq \text{Inst}(x, \text{red}) \wedge \text{Color}(\text{red})$
- **piu' avanti si potrebbe anche dire che in effetti bisogna capire CHI ha le proprieta': “ x is an apple with color red” vs. “ x is a red with shape apple”**

76 The dolce ontology

DOLCE: a Descriptive Ontology for Linguistic and Cognitive Engineering

- Strong cognitive bias: descriptive (as opposite to prescriptive) attitude.
- Emphasis on cognitive invariants.
- Categories as conceptual containers: no deep metaphysical implications wrt true reality.
- Clear branching points to allow easy comparison with different ontological options.
- Rich axiomatization.

77 dolce 2.1 basic taxonomy

Endurant

Physical

Amount of matter

Physical object

Feature

Non-Physical

Mental object

Social object

Perdurant

Static

State

Process

Dynamic

Achievement

Accomplishment

Quality

Physical Quality

Spatial Location

...

Temporal Quality

Temporal Location

...

Abstract Quality

Abstract

Quality Region

Time Region

Space Region

Color Region

...

78 Endurants (Objects)

- All their proper parts are present whenever they are present (wholly presence, no temporal parts).
- They can genuinely change in time.
- They exist in time but they are primarily in other dimensions (e.g. space for material objects).
- Typical properties that apply to (material) objects are: weight, size, shape, texture, etc.
- Space plays an important role in the identification of (material) objects: objects with different spatial locations are different.

79 Perdurants (Events)

- Only some of their proper parts are present whenever they are present (partial presence, temporal parts).
- At every time a perdurant exists it has a different temporal slice/part.
- They happen/occur in time, and they are primarily in time.
- Events can be sudden, brief or prolonged, fast or slow, etc. They can occur before, after, simultaneously to other events.
- Time plays an important role in the identification of events: events with different temporal locations are different.

80 Properties

- **Predicates.** Adequate to model the *basic elements* of the user's conceptualization and the categories/primitive relations of DOLCE. The formalization of properties as extensional predicates is straightforward and requires no special formalism.
- **Concepts** (in DOLCE 3.0). Concepts are properties *reified* in the domain of quantification to consider the intensional, contextual, or dynamic aspects (roles). A sort of instantiation relation (classification) needs to be introduced in the theory.
- **Qualities and quality spaces.** In addition to the intensional, contextual, and dynamic aspects of concepts, properties are *structured* (possibility of talking of the relations btw properties) in spaces according to specific points of view, instruments, etc.

81 Individual qualities and Quality spaces

- Every entity comes with certain qualities that permanently *inhere in* it and are unique of it.
- Qualities are *located in* regions of quality spaces.
- Properties hold because qualities have certain locations in their quality spaces.
- Each *quality type* has at least one associated quality space, but qualities can be located in different spaces.

82 Linguistic evidences about qualities

- This rose is red.
- Red is a color.
- This rose has a color.
- The color of this rose turned to brown in one week.
- The rooms temperature is increasing.
- Red is opposite to green and close to brown.

83 Ontological commitment

forse qui starei sul generico all'inizio, semplicemente dicendo che il framework e' abbastanza neutro rispetto alla natura delle proprietà', che adesso andiamo a studiare, poi riprendere alla fine la slides facendo vedere come le stesse formule possono essere interpretate in maniera diversa, anche in termini di teoria della misura.

In qualche maniera, qui sto dicendo che la stessa sintassi puo' avere diverse semantiche, e quindi in questo senso e' piu' neutra dal p.to di vista ontologico.

collegamento con il discorso della logica modale

- This general framework **L'ULTIMO, QUELLO CON INST** is quite neutral with respect to the ontological nature of objects, regions, and location:

► **universalism**

regions \Rightarrow *universals*, location \Rightarrow *instance of*;

► **conceptualism**

regions \Rightarrow *concepts*, location \Rightarrow *classification*.

► **aggiungere interpretazioni in base a trope-theory e resemblance nominalism**

84 Qualities and qualia

- Linguistic evidence
 - This rose is red
 - Red is a color
 - This rose has a color
 - The color of this rose turned to brown in one week
 - Red is opposite to green and close to brown
 - The patients temperature is increasing
 - The doctor measured the patient's temperature
- Each endurant and perdurant comes with certain qualities that permanently inhere to it and are unique of it
- Qualities are perceptually mapped into qualia, which are regions of

quality spaces.

- Properties hold because qualities have certain locations in their quality spaces.
- Each quality type has its own quality space

85 Quality spaces and qualitative modeling

Vedi Forbus *qualitative representation* (QR) in hand KR

- QR quantize continuous properties → symbolic reasoning and abstraction but it introduces ambiguity (p.362)
- (p.365) From continuous (one-dimensional) parameter to QR: (1) choose the (finite) set of *values*; (2) how to reason with values (propagation of value information through qualitative relationships); (3) how values can be generated from other sources.
- The *quantity space* representation for a quantity Q defines the value of Q in terms of ordinal relationships with a set of other quantities, the *limit points* for that quantity space. (p.367)
- Quality spaces can be partially ordered. A *value space* is a totally ordered quality space.

86 Quality spaces, individual qualities and NIST

- **vedi vecchie slides per Font05 dove avevo messo dei link sulla definizione di quantity/quality**

87 Tropes: determinable vs. determinate properties

- let us suppose to have a scarlet rose r : both 'the scarlet of r ', 'the red of r ', and 'the color of r ' exist and are distinct or only one of them exists?
- how change is represented by means of tropes?
 - ▶ individual qualities are more general than tropes, similar to the idea that objects is more general, is compatible, both with a 3d and a 4d approach
 - ▶ Cleland assumes that concrete phases are tropes relative to determinable properties P that survive the change of tropes that are relative to determinate properties that are specializations of P .

88 Tropes: examples and individuation

- the same basic determinate property can be instantiated by different objects at different times
- the same object at the same time can instantiate different basic determinate properties
- the same if we assume the spatiotemporal regions instead of tropes
- **visto che quest'argomento e' importante per le teorie degli eventi di Bennett, Lombard, Cleland ed in fondo anche per Kim, forse si puo' parlarne direttamente qui**

89 Particularity vs. Bundles

Is *particularity* a fundamental ontological category, or are particulars just *bundles of properties*, i.e. particulars are “constructed” from properties?

- *Ontologically*, this is a very important question because it address directly the problem of what are the basic entities in the world.
- *Representationally*, the expressive power of bundles theories is equivalent to the expressive power of theories based on particulars and the two alternatives have some advantages and drawbacks (in particular taking into account change and extrinsic/intrinsic properties).

Assumption. In order to simplify the comparison, here we consider particularity as a fundamental category.

90 The old problems of “universals”

- *One over Many*

How can different things be of the same type?

How a and b can both be F , can both have the property F ?

- *Many over One*

How the same thing can have different properties?

How a can be both F and G ?

- These two problems are intimately related to the analysis (in terms of truth-makers or conceptual analysis) of the following sentences:

- ▶ a is F ;

- ▶ a has the *property* F .

91 Properties

- Alternative names:
attributes, qualities, features, characteristics, kinds, sorts, types, universals
- Do properties exist?
We don't know, but it is important to represent the properties of things.
- Which properties there are?
 - ▶ No wholly uncontroversial, but largely accepted, examples: color, mass, height, etc.
 - ▶ Only *contingent* properties, or also *necessary* ones?
 - ▶ Only unary properties, no relations.

92 Universalism

Answer: a is an instance of the **universal** *being* F (F in the fig.).

- Categories: *particular* and *universal*.
- Relation: *instantiation*, I : particular \times universal.
- ▶ Universals are *wholly* present in their instances; they are constituent parts of the instances **while** classes are *partially* present in their instances; the instances are the constituents of classes.
- ▶ Universals are *sparse* and *minimal* to capture all the distinctions in the world **while** classes are *redundant* and *abundant*.
- ▶ **Natural classes.** Properties are considered as classes, and the *natural* ones correspond to “universals”.

93 Natural classes

Answer: a is a member of a *natural class*.

- Categories: *particular* and *class*.
- Relations and predicates:
membership, \in : particular \times class;
being a natural class

94 Trope theory

Answer: there is a trope *inherent* in *a*, the *a*'s *F*-ness, and this trope belong to the class of *F*-ness tropes, builded on the basis of *resemblance* relation.

- Categories: *particular*, *trope*, and *class*.

- Relations:

inherence $i : \text{trope} \times \text{particular}$

resemblance $\approx : \text{trope} \times \text{trope}$

membership $\in : \text{trope} \times \text{class}$

- ▶ Universals are substituted by maximal classes of resembling tropes.
- ▶ **Resemblance Nominalism** considers particulars and classes of resembling particulars (resembling couples, etc.).

95 Universalism and Trope theory

The two theories are compatibles: it is possible to have both universals and tropes:

- Categories: *particular*, *trope*, and *universal*.
- Relations:

inherence $i : \text{trope} \times \text{particular}$

instantiation $I : \text{trope} \times \text{universal}$

Note. The *resemblance* relation can be defined by means of the *instantiation* in the following way:

$$x \approx y \triangleq \exists F (I(x, F) \wedge I(y, F))$$

96 Substantivalism vs. Relationism

- **Substantivalism:** time is a container-like manifold and what happens occupies it *contingently*.
- **Relationism:** time is derived from relationships between events.
- Analogously for space: space as a container vs. space as a conceptual construction.

97 Parallelism with theories of properties

- **Substantivalism and Universalism.**

- ▶ Properties (called *universals*) are primitive and independent from their instances (*particulars*).

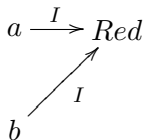
- **Relationism and Trope theory/Resemblance Nominalism.**

- ▶ (*Trope theory*) Properties are classes of *exactly resembling* tropes.
- ▶ (*Resemblance Nominalism*) Properties are classes of *resembling* objects.

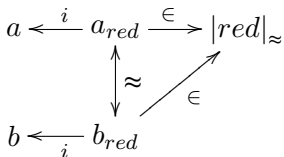
98 Main philosophical positions on properties

Example. The particulars a and b have the property “being red”.

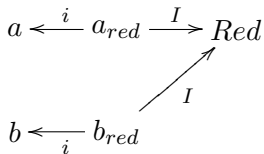
Universalism



Trope theory



Universals+Tropes



- **Natural classes.** Properties are classes of particulars, *natural* classes correspond to “universals”
- **Resemblance Nominalism.** Properties are classes of resembling particulars (resembling couples, etc.)

99 (??) Particularity vs. Bundles

Is *particularity* a fundamental ontological category, or are particulars just *bundles of properties*, i.e. particulars are “constructed” from properties (universals or tropes)?

- *Ontologically*, this is a very important question because it addresses directly the problem of what are the basic entities in the world.
- *Representationally*, the expressive power of bundles theories is equivalent to the expressive power of theories based on particulars and the two alternatives have some advantages and drawbacks (in particular taking into account change and extrinsic/intrinsic properties).

(??) in linea con BWW (che si focalizza alle thing), e per essere piu' neutri, non consideriamo necessariamente che i particolari siano riducibili a proprietà, quindi consideriamo sempre due tipi di entità:

particolari e proprietà

- **Bundles of tropes.** Beside an *exact resemblance* relation, a principle (or some principles) of *bundling* is necessary. In this case, particulars can be conceived (as universals) as equivalent classes of tropes (with respect to two different relations).
- **Bundles of universals.** Particulars are conceived as “classes” of universals (also in this case one or more equivalence relations are necessary). If extensionality is accepted, no two different particulars can be “constituted” by the same universals.

100 Universals vs. Classes

- Universals differ from classes because:
 - a. universals are *wholly* present in their instances (immanentism); they are constituent parts of the instances **while** classes are *partially* present in their instances; the instances are the constituents of classes;
 - b. universals are *sparse* and *minimal* to capture all the distinction in the world **while** classes are *redundant* and *abundant*.
[nota che nel caso della teoria dei tropi, le classi che considero sono soltanto classi di eq. di tropi, quindi sono anch'esse sparse ecc.]
- (??) forse qui e' piu' interessante dire qualche cosa sul fatto che nella teoria dei tropi senza universali, in qualcha maniera si

riducono le proprietà ad una astrazione rispetto ai tropi, quindi in questo senso le classi non sono di più degli universali, e sono soltanto un modo di astrarre

101 Things vs. Particulars

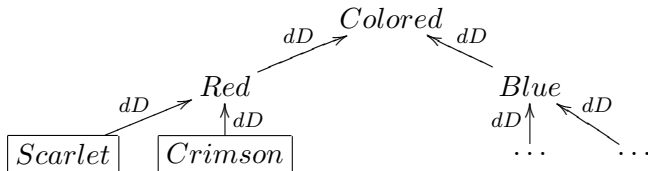
- BWW (and universalism).
(Post 1) The world is made of *things* that possess *properties*.
- Tropes inhere in (and existentially depend on) *things* and possess *properties*.
 - ▶ Note. The difference between tropes as *members* of classes of resembling entities vs. tropes as *instances* of universals is not relevant for the following arguments.
- Therefore, *tropes* are existentially dependent particulars.
In this sense they are conceptually similar to *weak-entities* and different from *things*.
- Can tropes inhere in tropes?

102 More specific goals

Show that a trope-based theory

1. can be used to provide an alternative (w.r.t. BWW) ontological interpretation of some CM fundamental constructs/notions;
2. leads to a more explicit ontological characterization of some of these CM constructs/notions;
3. allows for representing additional situations in an ontologically well founded way, e.g. change in time, properties of properties, measurement, etc.

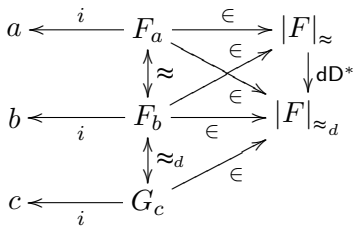
103 Qualia



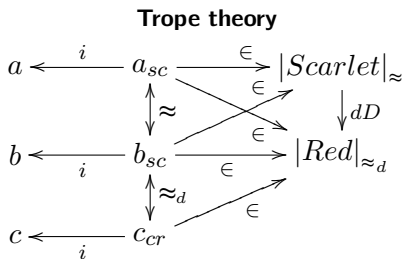
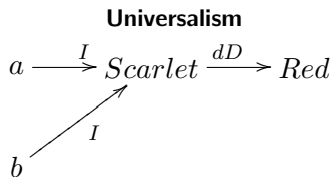
- $dD(p_1, p_2)$: property p_1 is a determinate of p_2 (the determinable):
 - ▶ having a *determinate* property entails having a *determinable* property;
 - ▶ having a *determinable* property entails having (at least) one of the properties that are its *determinates*.
- **Qualia**: determinates that are not determinables, i.e. the more specific properties (that, intuitively, correspond to values).

104 Trope theory and qualia

- The classes of *exactly* resembling tropes correspond to qualia.
- Introducing a resemblance *with degree* between tropes it is possible to define classes of *inexactly* resembling tropes and a resemblance relation between these classes.
- The classes of inexactly resembling tropes corresponds to determinable properties/concepts.

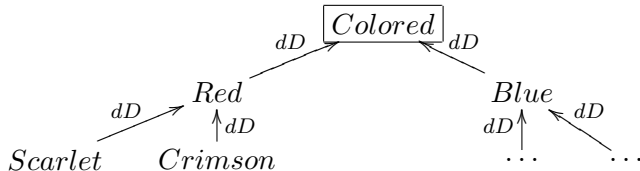


105 Predication of determinables



- Universalism. dD is (a) primitive; (b) based on resemblance with degrees *between universals*; (c) based on partial identity.
- Trope theory. dD is based on the inexact resemblance with degree d *between tropes* (\approx_d): classes of exactly (inexactly) resembling tropes are qualia (determinables, resp.).

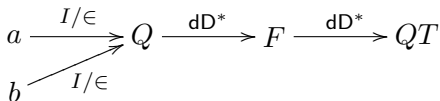
106 Qualia kinds



- *Incompatibility of qualia.* One (atomic) entity can have only a coloured-qualia (not the case of *Coloured_OR_Shaped*).
- *Comparability of qualia.* Coloured-qualia are at least qualitatively comparable (they are related). No coloured-qualia resembles more closely a shaped-qualia than a volume-qualia.
- **Qualia kinds** are maximal wrt incompatibility and comparability.

107 Qualia kinds (2)

- *Quality kinds* are determinable properties maximal w.r.t *resemblance/addiction* and with incompatible determinates.
- Quality kinds have different structures, e.g. *volume* is linear, *color* is a spindle, *shape* is ??, and the determinates are “points”.



- Some universalists consider *quality types* as universals while their determinates (that are no qualia) just as *concepts*/classes of determinates.
- (??) *Qualities* (\neq individual qualities) are determinates of a quality type (e.g., for *color*: red, yellow, scarlet, dark-scarlet).

108 Comparability

- Comparability (cm) seems at least an equivalence relation on qualia (reflexive, symmetric, and transitive).
- cm -equivalence classes (let suppose a finite number QK_1, \dots, QK_n) form a partition of qualia.
- Comparability seems to imply incompatibility: if $cm(q_1, q_2) \wedge q_1 \neq q_2$ then it is not possible that one particular (at the same time) is an instance of both q_1 and q_2 .
- Therefore the qualia that are determinates of QK_1, \dots, QK_n are also incompatible, and QK_1, \dots, QK_n are *qualia kinds*.

Question. Is comparability a primitive relation?

109 Comparability and orders (1)

- Peter Simons: quantities are subject of comparison (greater or lesser).
- Let introduce a binary relation (\preceq) between qualia that is reflexive, transitive, and for which the following properties hold:

$$(x \preceq z \wedge y \preceq z) \rightarrow (x \preceq y \vee y \preceq x)$$

$$(z \preceq x \wedge z \preceq y) \rightarrow (x \preceq y \vee y \preceq x)$$

- On the basis of \preceq , an equivalence relation cm is definable:

$$cm(x, y) \triangleq x \preceq y \vee y \preceq x$$

110 Comparability and orders (2)

- The QK_i are maximal with respect to cm .
- In every QK_i the following constraints hold:

$$x \preceq y \vee y \preceq x \quad (\text{connectedness})$$

$$(x \preceq y \wedge y \preceq z) \rightarrow x \preceq z \quad (\text{transitivity})$$

- Therefore, if QK_i is finite and non empty, there exists an *ordinal scale* ϕ on QK_i .

Question. Is it enough to call these qualia, *quantitative qualia* (quantities)?

111 Comparability and orders (3)

- To \preceq it is possible to add a *concatenation* relation in any QK_i , select a unity and therefore introduce an *extensive measurement*.
- In this case we rely on the existence of concatenation (i.e. given two qualia there exists the concatenation quale).
- This axiom has been criticized when concatenation applies directly on physical particulars, in this case for any two particulars x and y it guarantees the existence of another particular whose magnitude is the sum of those of x and y .
- Assuming that all the properties are non empty, I don't know if concatenation between properties is less critical (unless considering modality).

112 Comparability (4)

- Why comparability is defined on qualia and not on tropes?
- Is comparability, or different kinds of comparability relations definable directly on particulars? (here we necessarily need a duplication of comparability relations)

113 Comparability and similarity

- Ingvar Johansson: certain qualities cannot be ordered even if a n -dimensional space is considered.
- Instead of an order relation, a qualitative ternary *similarity* relation on qualia is considered: $sm(x, y, z)$ stands for “quale x is more similar to quale y than to quale z ”.
- An comparability relation is definable on the basis of sm .

114 Open questions (at least for me)

- What axioms characterize a similarity relation?
- Is an (pre-)order relation definable on the basis of a similarity relation?
- Is a similarity relation definable on the basis of a (pre-)order relation?

115 Comparability relation/comparability relations

- Right now we have considered only a general comparability relation defined on all the qualia.
- Once the qualia kinds are determined, can we add more specific and strong “structural constraints” on them?
- Does this make sense, or different comparability relations (or different kinds of comparability relations) need to be considered from the beginning?
- In this case, are both qualia kinds and specific compatibility relations ontologically primitive? Are we losing the generality of approaches based on qualia coming back to classical measurement theories?

116 Contextual orders/similarities

- Let's consider qualia and qualia kinds as absolute and non-contextual (i.e. let's suppose that the dD and cm relations are fixed and absolute).
- Is it possible to manage *contextual* orders/similarities/etc. “organizing/structuring” the same qualia in different ways?
- Is it possible to manage qualia kinds at different levels of “granularities”, i.e. deleting from them some qualia?

Link. Erwin Tegtmeier: the nature of mappings btw the three levels of sequences is different: objects \rightarrow quantities (objective), quantities \rightarrow numbers (subjective/conventional).

117 Ordinal scale

- An *ordinal scale* ϕ on QK_i is a real valued function on QK_i , such that for each $x, y \in QK_i$:

$$x \preceq y \text{ iff } \phi(x) \leq \phi(y)$$

and for each ϕ' that is a real valued function on Q_i , there is a strictly increasing function f (with domain and range equal to reals), such that for each $x \in Q_i$:

$$\phi'(x) = f[\phi(x)]$$

118 Qualia kinds and comparability

- On the basis of an equivalence relation a partition of the domain in equivalence classes is always possible.
- But, are all these classes, all the QK_i builded in this way interesting?
- For example, it is possible that some QK_i has only one qualia as member?
- Does this make sense or we need to put some cardinality constraint in order to have quality kinds with only a member?

Alternative representations of attribute functions in UML:



- In UML, a *datatype* is a class whose instances are *values* not *objects*. A value does not have an identity: two occurrences of the same value cannot be differentiated:

color: $\text{Apple} \rightarrow \text{Color}$

- In BWW, **Apple** is a set of things, *Color* is a set of values, and color is a property (an attribute). A set M representing the “observation conditions” (times, contexts, etc.) is added.

color: $\text{Apple} \times M \rightarrow \text{Color}$

120 Attribute Functions

(2/5)

- Intuitively, “being coloured” is different from “being red” or from properties individuating a specific color shade.
- Each value in *Color* individuates a specific property, e.g. “being scarlet”, “being crimson”, etc.
- *Color* (and color) individuates the set of *specific properties* (by means of values) that specialize a “common aspect”, a general property, of things, “being coloured” in this case.
- In trope theory, specific properties are classes of *exactly* resembling tropes.
- (?) How can these notions (specific vs. general properties) be characterized in a trope-based theory?

121 Attribute Functions

(3/5)

Let us make use of the distinctions just introduced to interpret the attribute functions.

We introduce:

1. the set of things **Apple**;
2. the qualia kind (a set of inexactly resembling tropes) **Colored**;
3. the (second order) axiom

$$\mathbf{Apple}(x) \rightarrow \exists t, Q(i(t, x) \wedge Q(t) \wedge dD(Q, \mathbf{Colored}) \wedge \neg \exists Q'(dD(Q', Q)))$$

Note. In BWW given a $m \in M$, the value of an attribute needs to be defined:

$$(x \in \mathbf{Apple} \wedge m \in M) \rightarrow \exists v \in \mathbf{Color}(\mathbf{color}(x, m) = v)$$

122 Attribute Functions

(4/5)

To avoid second order quantification, we reify qualia kinds and their determinates:

- colored is the reification of the attribute (qualia kind) Colored;
- q is the reification of property Q that is a determinate of a qualia kind, in particular qualia are identified by:

$$\text{Qualia}(q) \text{ iff } \neg \exists q' (dD(q', q))$$

- a *classification* relation ($::$) between tropes and properties is introduced (a generalization of membership and instantiation).
- The previous axiom can be rewritten as:

$$\text{Apple}(x) \rightarrow \exists t, q (i(t, x) \wedge \text{Qualia}(q) \wedge t :: q \wedge dD(q, \text{colored}))$$

123 Attribute Functions

(5/5)

- A function *color* from *things* to *qualia* can be defined as:

$$\text{color}(x) = q \text{ iff } \exists t(i(t, x) \wedge t :: q \wedge dD(q, \text{colored}))$$

assuming the incompatibility of qualia of the same quality kind:

- ▶ $(i(t, x) \wedge t :: \text{colored}) \rightarrow \neg \exists t'(t \neq t' \wedge i(t', x) \wedge t' :: \text{colored})$
- ▶ $t :: \text{colored} \rightarrow \exists q(\text{Qualia}(q) \wedge t :: q \wedge dD(q, \text{colored}))$

Two basic differences with respect to the color function in BWV:

- the additional argument (*M*) is missing;
- color yields now “qualia” instead of “values”
(we will go back to this point).

124 Time and change in time

- One of the reason of the argument M in BWW is the encoding of the change of properties of things through time.
- Like other particulars, tropes can have a temporal extension.
- Let us suppose that the function **time** yields the temporal extensions of particulars, then, we can introduce a temporal argument in the previous **color** function:

$$\text{color}(x, m) = q \text{ iff } \exists t(i(t, x) \wedge \text{time}(t) = m \wedge t :: q \wedge dD(q, \text{colored}))$$

- ▶ change in time as *substitution* of tropes;
 - ▶ explicit recording of the “color history” of an object.
- Note. The same can be done for relationships.

125 Universalism on change

Different solutions:

- The introduction of a temporary instantiation relation: a is an instance of the universal F at t_1 and of G at t_2 . In this case I is a ternary relation, *instantiation-at* among particulars, universals, and times.
- The introduction of a temporal “modal” operator, i.e. I remains a binary relation on which some modal operator applies.
- The commitment on a four-dimensionalist ontology of particulars: $a@t_1$ is F , and $a@t_2$, different from $a@t_1$, is G .

We do not commit on one solution; we simply write I_{t_1} .

126 Trope theory on change

- The “standard” solution consists in the introduction of two tropes, the a ’s being F , and the a ’s being G , respectively existing at t_1 and t_2 .

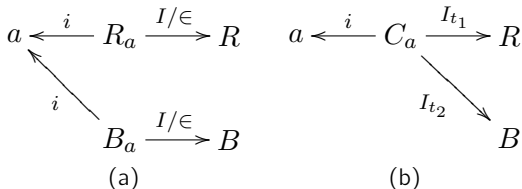
Change is reduced to a *substitution* of tropes.

- (??) additional solutions, maybe too complex to explain

127 Universals+Tropes on change

Example. a is Red (R) at t_1 and Blue (B) at t_2 .

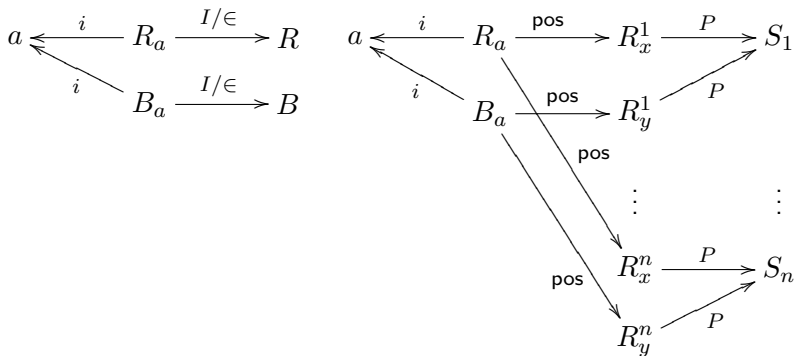
- (a) *Substitution.* Two tropes (as in the case of only tropes) that are instances of R and B existing, respectively, at t_1 and t_2 .
- (b) *Variation.* Only one “more general” trope, the color (C) of a , existing during t_1 and t_2 , and a relation of instantiation I_t . In this case we have a generalizations of the concept of quality admitting *degrees* introduced by Campbell.



128 Come back to the example (1)

Example. a is Red (R) at t_1 and Blue (B) at t_2 .

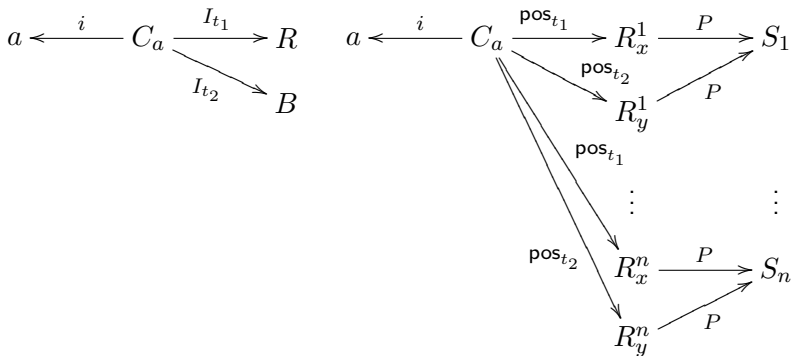
- With respect the solution with *substitution*:



129 Come back to the example (2)

Example. a is Red (R) at t_1 and Blue (B) at t_2 .

- With respect the solution with *variation*:



130 Attributes of Attributes

(1/2)

- In the previous example, the function *time* can be seen as an attribute of tropes that yields temporal qualia.
- Consequently, we admit tropes that inhere in tropes.
- Very useful in the case of complex tropes like *symptoms*, e.g. John's headache and influenza are tropes inhering in John and they are different from the ones inhering in another patients.
- Different *symptoms* can:
 - ▶ occur at different times;
 - ▶ have specific temporal/causation relations;

131 Attributes of Attributes

(2/2)

Another interesting representational problem regards roles, e.g.:

- if the instances of **Customer** are persons (or organizations) and **code** is an attribute of **Customer**, therefore to each person it is possible to associate only one customer code.

But, at the same time, the same person can be customer of different stores, therefore he can have a multitude of different codes, one for each store.

- A possible solution consists in introducing **code** as an attribute of a class of (relational) tropes that inhere in persons and stores.

132 Qualia vs. Values

- What is the ontological nature of values in BWW?
 1. Can the same value be used for different attributes? For example, can “1m” be used for *height* and *length*?
 2. Do “1m” and “100cm” refer to two different values?
- Qualia are specific properties, therefore “being 1m high” and “being 1m long” are just two different properties.
- The same qualia can be “measured” in different ways: “being 1m high” and “being 100cm high” refer to the same property but to different *measurement systems*.
- “m” and “cm” can refer to different granularities or measurement’s precisions.

133 Ontological similarity

- Universalism and trope theory both consider a “jugement” of *similarity* between (particular aspects of) objects.
- This “jugement” is based on having some “common property”: two objects are *similar*, in some way, iff
 - ▶ they share a universal (*universalism*);
 - ▶ they have resemblant tropes (*trope theory*).
- The *similarity* is *objective*, *mind* independent, *language* independent, it is exclusively based on the *ontological nature of objects*, and it provides the *finest* possible analysis on aspects of objects.

134 Empirical/epistemological level

- In *cognitive science*, similarity is a central notion:
“[J]udgments of similarity (...) are central for a large number of cognitive processes. (...) such judgments reveal the dimensions of our perceptions and their structures.”
- In this case, *similarity* is empirically built on experiments and it is *relative*: it may depend on species, cultures, etc.
- In *science*, the analysis always is conducted at an empirical (or theoretical) level and it depends on the available information, the measurement instruments/methods, etc.
- It is possible to have different granularities of analysis or qualitative ones and it may interesting to have a way to compare these different analysis.

135 Spaces of properties

(1/3)

- Objects sharing a *quale* are *exactly similar* (w.r.t. some given aspect).
- In general, objects sharing a *determinable* are *inexactly similar*, i.e. they resemble each other with a *degree*.

But *in applications*, we find a variety of degrees of resemblance

- they are *empirically* determined by the chosen experiments and depend on species, culture, available information, measurement instruments and methods, etc.
- they furnish (roughly speaking) spaces of properties with quite different structures.

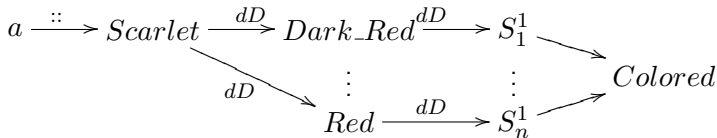
- Resemblance with *degree* simply introduces a partial order among properties.
 - ▶ Spaces have more structure: they add further relations like those determining a topological or geometrical space.
- Each qualia kind is associated to (can be structured in) one or more spaces which depend on culture, instruments of investigation, etc.
- Spaces exist *in time*: they are created, adopted, and destroyed by (communities of) intentional agents.

137 Spaces of properties

(3/3)

Taking exact similarity and qualia to be *objective*, they are *contextually* organized in spaces.

- Qualia are linked to possibly different *properties* in spaces.



- Structuring relations can be added into specific spaces, e.g. $\text{Connected}(B)$
- Different granularities can be assumed in different spaces, e.g. *Dark_Red* is not considered in space S_n^1 .
- Different measurement systems can be introduced in one space.

138 Multidimensional spaces

(1/2)

- Simple spaces can be composed in more complex spaces by means of *existential dependences* among tropes and qualia, e.g. the color space (trope) can be seen as composed by three spaces (tropes): hue, saturation, and brightness.
- Constraints (*laws*) on qualia in the same simple space or multidimensional spaces, e.g. the linearity of weights, or the splinter shape of the color space, can be introduced as constraints on relations between qualia.

139 Multidimensional spaces

(2/2)

Alternative spaces can be considered also for complex attributes like color:

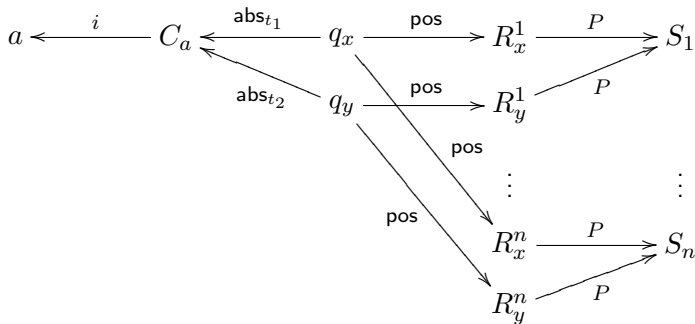
- We can map the same color-qualia $q = \text{color}(x)$ to different *regions* (in different spaces).
- Each region of space can be the result of the composition of other regions belonging to simpler spaces, for example the hue, saturation, and brightness spaces.
- The qualia kind is associated just to one *space kind*, i.e. all the color qualia are mapped to regions in color-spaces.

140 Reconstructing qualia

- If we assume that for each quality kind there is a space S^* with maximal granularity (as defined by, say, a *refinement relation*), then the atomic regions of S^* can be taken to be the “qualia”.

141 Being more ontological: qualia

Qualia represent *partial identities* between objects, and spaces represent different ways of organizing qualia. They do not inhere in specific objects, they are abstract from time, and they do not have any structure (only in variation approach).



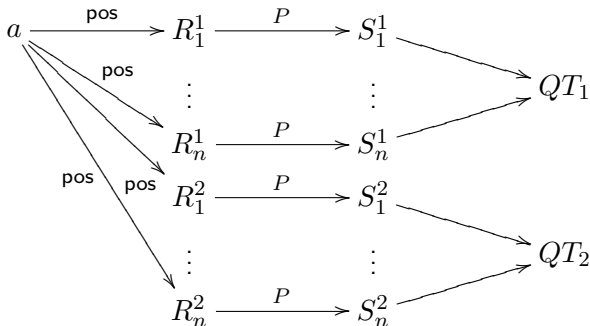
142 Qualia/spaces and determinates/determinables [DA VERIFICARE]

- Qualia are very similar to *determinates*, i.e. universals that can not be further reified. In this sense they are similar to classes of resembling tropes: they are abstract from a specific entity, but they represent the “finer granularity”.
- Regions in spaces can be viewed as abstraction on determinates, in this sense they are similar to *derterminables*.

143 Are qualia necessary? (1)

Conceptual Spaces organize directly objects not qualia.

- pos relation can be interpreted as: (i) *I*, i.e. there are different qualia for each space; or (ii) \in , i.e. different similarities btw object “generate” different classes (resemblance nominalism?).

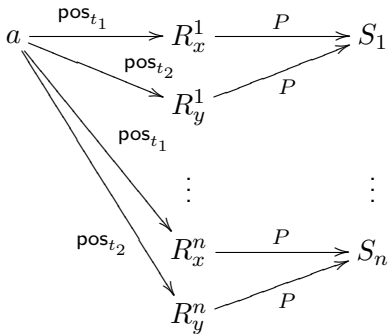


144 Are qualia necessary? (2)

- From the expressive point of view, the approach without qualia is equivalent to the one with qualia only if we presuppose, for each quality type, the existence of a maximal refined space.
- This solution is adequate for representing the *Conceptual Spaces*.

145 Being less ontological: objects and spaces

In *Conceptual Spaces*, objects are directly organized in spaces: the different similarity relations apply to objects.



A relation between spaces that refer to the “same” quality type of the objects is needed: colors, weights, heights, etc.

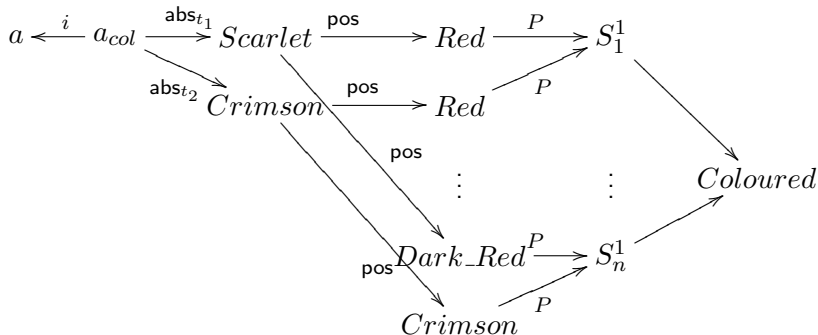
146 Individual qualities

- The idea is to consider the particular *aspect* of an object linked to a specific qualia kind:
 - The weight of John.
The color of the rose.
- We call these entities *individual* qualities because, like tropes, they inhere in a specific object (the weight of John is different from the weight of Sam).

147 Individual qualities and change

The rose a may “change” its color.

This change is represented (using qualia) in the following picture:



148 The International System of Units

- This approach (but without qualia) is adopted by the SI, where:
 - ▶ quantities in the *particular* sense correspond to individual qualities;
 - ▶ quantities in the *general* sense correspond to qualia kinds.

149 Reconstructing individual qualities

- With qualia, it is possible to reconstruct qualities of kind i as couples $\langle e, Q_i^{|e|} \rangle$, where e is a specific object, and $Q_i^{|e|}$ is the set of all the qualia of kind i that are linked to e .
- Without qualia, the reconstruction becomes possible if we assume a maximal refined space.
- In any case the construction is complex and is based on set-theoretical notions (or mereological in alternative)
- Clearly individual qualities offer a closer interpretation of sentences like “The weight of John”, but it is not clear if they add something to the formal language from the expressive point of view.

Our goal is to compare objects in a relationist setting.

- In the case of time and space, tropes are not considered
but
the relations allowing to construct time from events are different from the relations used to construct space from physical objects.
- Resemblance nominalism admits just one resemblance relation
but
it has problems to differentiate co-extensional properties.

We begin with a system:

$\langle D, \equiv^1, \dots, \equiv^n \rangle$, where \equiv^i are resemblance relations on D , which allows us to overcome the problems in resemblance nominalism, and to adopt a methodology similar to that of time/space construction.

- It is stronger than resemblance nominalism because of the presence of n different resemblance relations.
- It is weaker than trope theory because tropes cannot be reconstructed in it **but** tropes theorists can rephrase our formalization adopting:

$\langle D, T^1, \dots, T^n, i, \equiv \rangle$, where the T^j are disjoint sets of tropes, and i is the inherence relation

$$x \equiv^j y \text{ iff } \exists t, s \in T^j (i(t, x) \wedge i(s, y) \wedge t \equiv s)$$

152 Abstraction process

- $\mathcal{S} = \langle D, \equiv \rangle$ is a generic structure with one *equivalence* relation.
- $\mathcal{S}^e = \langle D^e, =^e \rangle$ is the *abstraction* of \mathcal{S} , where
 - ▶ D^e is the set of (non-empty) equivalence classes of D ;
 - ▶ $=^e$ is the equality on D^e .
- Examples:
 - ▶ different (punctual) events can be temporally co-localized from $\mathcal{E} = \langle E, \equiv_E \rangle$, E set of *events*, \equiv_E *temporal coincidence* to $\mathcal{T} = \langle T, =^e \rangle$, T set of *times*.
 - ▶ different objects can have the same color from $\mathcal{O} = \langle O, \equiv^c \rangle$, O set of *objects*, \equiv^c *color resemblance* to $\mathcal{C} = \langle C, =_C \rangle$, C set of *color properties*.

- *Structural constraints* are normally introduced in modeling time (and space), e.g. a precedence relation can force time to be linear or branching, a congruence relation can constrain the metric, etc.
- These structural constraints are not uncommon for *quality kinds* like color, length, volume, shape, mass, etc. For example, a RGB structure can be assumed for colors, and weights are usually linearly arranged.
- Different quality kinds have different structures, therefore, in general, we will apply structural constraints separately for each quality kind.

- $\mathcal{S}' = \langle D, \equiv, R \rangle$ is the extension of \mathcal{S} with the structuring relation R .
- $\mathcal{S}'^e = \langle D^e, =^e, R^e \rangle$ is the abstraction of \mathcal{S}' where
 - ▶ $x^e R^e y^e \text{ iff } \exists a \in x^e, b \in y^e (a R b)$.
- In general, it is possible to have different structuring relations relative to the same abstraction process; for example:
 - ▶ $\mathcal{E}_{cg} = \langle E, \equiv_E, \triangleleft_E, \preceq_E \rangle$ is the event structure augmented with the *precedence relation* \triangleleft_E and the (quaternary) *congruence relation* \preceq_E among (punctual) events;
 - ▶ $\mathcal{T}_{cg} = \langle T, =^e, \triangleleft_T, \preceq_T \rangle$ is the associated abstraction, where: \triangleleft_T is the abstraction of \triangleleft_E while \preceq_T is the abstraction of \preceq_E .

- The definition of R^e in terms of R :
 - ▶ $x^e R^e y^e$ iff $\exists a \in x^e, b \in y^e (a R b)$.
is compatible with: $c \equiv a$, $d \equiv b$, $a R b$, $\neg(c R d)$, and $c^e R^e d^e$.
- Using an universal quantifier, the same problem arises considering 'negative' statements.
- It is possible to constrain 'homogeneity' by means of:
 - ▶ $x \equiv y \rightarrow \forall z (z R x \leftrightarrow z R y)$.

- Technically, structuring relations can be introduced in the *abstraction* structure. R can then be defined in terms of R^e :
 - ▶ $a R b$ iff there exist $x^e, y^e \in D^e (x^e R^e y^e \text{ and } a \in x^e, b \in y^e)$
- Philosophically, the introduction of structuring relations in the starting structure or in its abstraction, can reveal an objective/ontological vs. subjective/epistemological attitude towards these relations.
- To have a direct parallelism with the construction of time, we introduce all the structuring relations in the starting structure. This does not prevent us from considering them as “ontological” or as “epistemological” relations.

157 Extending our setting

- To each \equiv^i we associate a set of structuring relations, obtaining:
 - ▶ $\langle D, \equiv^1, \dots, \equiv^n, R_1^1, \dots, R_{m_1}^1, \dots, R_1^n, \dots, R_{m_n}^n \rangle$that allows for the comparison of entities in the same world.
- To compare entities ‘living’ in different worlds, we need to extend the formalism with:
 - ▶ a set of possible worlds W ;
 - ▶ the relation $a \downarrow_w$ standing for “ $a \in D$ is in the world w ”:obtaining:

$$\langle D, W, \downarrow, \equiv^1, \dots, \equiv^n, R_1^1, \dots, R_{m_1}^1, \dots, R_1^n, \dots, R_{m_n}^n \rangle$$

158 A classical puzzle

Let us assume that:

1. \equiv^i is independent from \downarrow , in particular it is a cross-world relationship;
2. entities can change, with respect to the quality kind i , through worlds.

For example, let us assume a persistent entity a (an entity that is in two different worlds, i.e. $\exists w, w'(a \downarrow_w \wedge a \downarrow_{w'} \wedge w \neq w')$), that is red in w and yellow in w' .

- We get a contradiction if we include a in the class of the red entities as well as if we put it in the class of the yellow ones.

159 Each view has its solution

rivedere queste cose in base al tempo invece che mondi possibili

- **Lewis & stage theory.** Entities are world bounded and modality is interpreted by means of the *counterpart* (C) relation: $a \downarrow_w \wedge a' \downarrow_{w'} \wedge C(a', a)$ and a is red while a' is yellow.
- **Perdurantism.** An entity a has different *world stages* a/w in each world w to which it belongs: “ a is red *at* w ”, because it has a world stage a/w that it is red. Analogously for “ a is yellow *at* w' ”.
- **Endurantism.** Cross-world change requires the introduction of a world argument in the properties: a is not red in general, it can be red relatively to a world which must be specified.
Criticism: *de facto* negation of *intrinsic properties*, all the properties become relations with the worlds.

160 Our approach (driven by info systems' scenario)

- Equivalence classes of resembling entities are *localized* in single worlds, i.e. a world argument is added to resemblances:

▶ $a \equiv_w^i b$ stands for “ a i -resembles b in the world w ”.

⇒ **Weak endurantism**: we only know the classes of objects that, in a given world, are indistinguishable with respect to one quality kind, but we don't have any cross-world relation between these equivalence classes (called *qualities*) .

- ▶ Given the class of red objects in one world, one has no way to infer which is the red class in a different world.
- ▶ We are interested in understanding whether and on which assumptions an equivalence at the level of qualities in the two worlds can be established without additional primitives.

161 Gathering ideas from the construction of time in branching-worlds

- **Forbes:** in each world, times and relations on times are abstracted from (i) the set of punctual events and, (ii) the *coincidence* (\equiv_E), *precedence* (\triangleleft_E), and *distance* (d_E) relations.
- *Branching-worlds* share an initial segment of their course of history, i.e. they share at least two (punctual) *times* that fix a common *origin* and *unit* of measure allowing for the definition of a unique d_T on times in branching worlds.
- A correspondence between localized times in *different* branching-worlds can be established in the following way:
 - ▶ $t_1 \equiv_T t_2$ iff $d_T(t_1, t) = d_T(t_2, t) \wedge t \triangleleft_T t_1 \wedge t \triangleleft_T t_2$.

162 Tuning systems

Tuning systems: aligning, finding correspondences between, **qualities** (i.e. equivalence classes of objects) in different worlds.

- Following Forbes, one should assume the existence of objects that, with respect to the quality kind considered, are invariant across (branching) worlds (the shared segment).
By means of these invariant objects, correspondences between equivalence classes can be established.
- Our goal is to extend (and weaken) this notion of ‘shared segment’ to general worlds (that is, to worlds where a branching relationship is not defined) to make it applicable to objects and qualities.

163 Representing properties and relations as predicates

DA langOnto09-p1

- \mathcal{T}_1 and \mathcal{T}_3 use the same predicates. Suppose that \mathcal{T}_3 uses new predicates (e.g. using index 3 instead of 1: Gray_3 , White_3 , etc.)
- In this case, $\mathcal{T}_1 \cup \mathcal{T}_3 \cup \{\mathbf{a}\}$ and $\mathcal{T}_1 \cup \mathcal{T}_3 \cup \{\mathbf{b}\}$ are consistent but we loose the link between predicates that in our mind represent the same property, e.g. Gray_1 and Gray_3 .

BUT if we identify Gray_1 with Gray_3 and White_1 with White_3 :

c $\forall x(\text{Gray}_1(x) \leftrightarrow \text{Gray}_3(x))$

d $\forall x(\text{White}_1(x) \leftrightarrow \text{White}_3(x))$

then $\mathcal{T}_1 \cup \mathcal{T}_3 \cup \{\mathbf{a}, \mathbf{c}, \mathbf{d}\}$ is inconsistent (the same if we identify Supp_1

with Supp_3).

- Therefore, introducing different names for the 'same' primitive does not help in solving the problem.

164 Open- vs closed-world

- In FOL, we are able to distinguish different properties that **can be** (but are not necessarily) ‘co-extensional’ by introducing different *predicates*.

Gray₁ is not necessarily identical to Triang₁ even if the we know that:

$$\mathbf{e} \quad \text{Gray}_1(a) \wedge \text{Gray}_1(b) \wedge \text{Triang}_1(a) \wedge \text{Triang}_1(b)$$

i.e. from **(e)** it does not follow that $\forall x(\text{Gray}_1(x) \leftrightarrow \text{Triang}_1(x))$.

- This is due to the fact that in FOL we don’t have a closed-world assumption: “*what is not currently known to be true is false*”.

Therefore we don’t know, for example, if Gray₁(d) or $\neg\text{Gray}_1(d)$ and if Triang₁(d) or $\neg\text{Triang}_1(d)$. Because we don’t know we cannot

identify Gray_1 with Triang_1 .

- This is not true in the case of sets:

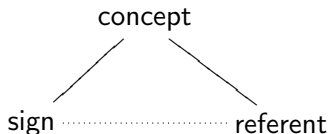
if $\text{Gray}_1 = \{a, b\}$ and $\text{Triang}_1 = \{a, b\}$, then $\text{Gray}_1 = \text{Triang}_1$.

165 Extension vs intension

(1/3)

- Intuitively, the properties/concepts used to model the two situations are the same.
- For example the property/concept 'being gray' does not change just because some objects change color.
- But we have seen that, assuming some very basic and intuitive constraints, the theories that model the two situations become incompatible.

- Consider the Peirce's 'semiotic triangle'



- Intuitively, concepts are the **rules** that make possible to individuate the **referents**, they are at a higher level of abstraction than their referents, and they are independent from them.
 - Similarly, **terminological knowledge** abstracts from specific individuals, it concerns general rules that govern the world, that characterize the 'kinds' of (or relations among) individuals in the domain.
- ⇒ Concepts and terminological knowledge are independent from the

configuration and the specific individuals of the world.

- How is it possible then to represent the way the domain is **conceptualized** independently from its **configuration**?
- How is it possible to reuse **the same model** to represent different **configurations**?
- How is it possible to catch the **intension** of properties/concepts (the rules that define them)?

Montague solution:

- to represent properties/concepts as *functions* from a set of **possible worlds** to a set of individuals (analogously for relations).
- For temporal change, we can assume that possible worlds are *temporal instants*.
- More formally, every concept/property is represented by a function P (where D is the domain of individuals, and W is the set of possible worlds):

$$P : W \rightarrow 2^D$$

- In the example, for “being gray” we can use the function $Gray$, such that $Gray(w_1) = \{a, b\}$ and $Gray(w_2) = \{a, d\}$ (were w_1 e w_2 corresponds to the world in which, respectively, the first and the

second situation take place).

- Similarly, in FOL it is possible to add to every (unary or n -ary) predicate an **argument** (for possible worlds):
 - $\text{Gray}(a, w_1) \wedge \text{Gray}(b, w_1) \wedge \text{Gray}(a, w_2) \wedge \text{White}(b, w_2)$;
 - $\text{Supp}(a, b, w_1) \wedge \text{Supp}(b, a, w_2)$.
- The previous problem is solved if we introduce, following intuition, a “**synchronic**” (assuming a temporal interpretation of possible worlds) version of axioms (**a**) and (**b**) as:
 - a'** $\forall x, w (\text{Gray}(x, w) \rightarrow \neg \text{White}(x, w))$;
 - b'** $\forall x, y, w (\text{Supp}(x, y, w) \rightarrow \neg \text{Supp}(y, x, w))$.

- It is also possible to consider a completely different ontological theory on persistence through change called **four-dimensionalism**.
- This theory commits to the existence of temporal slices of objects at every world in which they exists, therefore
 - $\text{Gray}(\mathbf{b}, w_1)$ can be reduced to $\text{Gray}(\mathbf{b}@w_1)$.
 - $\text{Gray}(\mathbf{b}, w_1) \wedge \text{White}(\mathbf{b}, w_2)$ is not contradictory because assuming that $\mathbf{b}@w_1 \neq \mathbf{b}@w_2$ (a basic assumption that four-dimensionalism takes in the case $w_1 \neq w_2$) $\text{Gray}(\mathbf{b}@w_1) \wedge \text{White}(\mathbf{b}@w_2)$ is perfectly consistent.
- Philosophical theories become then relevant to knowledge representation problems.

- From a modeling (and maybe theoretical) perspective, the Montague's approach is really demanding because it requires knowledge about all the possible configurations of the individuals in the world.
- It is the complete **factual** knowledge of each configuration of the world that determine the concepts.
- The FOL counterpart is less demanding because of the **open-world** assumption, i.e. for some individuals, in the world w we can **not** know if they are **Gray** or not in this world.

(?) Is it possible to capture the *invariances* we are interested in without assuming a sort of *omniscience*? And how?

172 Abstraction power of FOL

- FOL allows us to express general rules that characterize the primitive predicates independently from the domain of quantification and from specific configurations.
 - *Abstraction from specific **individuals***: the same theory can have a multitude of models that can have different domains.
 - *Abstraction from specific **situations***: the same theory can have a multitude of models that can have different relations (i.e. different interpretations of the predicates of the theory) or can be specialized in different ways adding factual knowledge.
- (!) Note that the constants of a theory are fixed even though they can be interpreted in different ways.

173 Conceptual characterization of primitives (1/7)

- In \mathcal{T}_1 and \mathcal{T}_3 we introduced axioms that state that a specific individual has a particular property or stays in a particular relation with other individuals: e.g. $\text{Gray}_1(a) \wedge \text{White}_1(c) \wedge \text{Supp}_1(a, c)$.
- This corresponds to the **factual** or **assertional** part of a knowledge base (and it is very close to a very simple relational DB).
- These theories tell us something about the individuals but not so much about the properties and relations: what Gray_1 , White_1 or Supp_1 mean is not captured, we just know that there are objects that satisfy properties represented by predicates Gray_1 , White_1 , etc.
- But FOL is quite expressive and allows to introduce **terminological** constraints that are independent from the individuals we have in the domain of quantification, that characterize the primitives from a **conceptual** point of view.

(!) Similar to the distinction: **data** vs **content**.

174 Abstraction power again

In which sense \mathcal{T}_c abstracts from the individuals and the situations?

- Abstraction from **situations**: \mathcal{T}_c is compatible both with \mathcal{T}_1 and \mathcal{T}_3 , i.e. both $\mathcal{T}_c \cup \mathcal{T}_1$ and $\mathcal{T}_c \cup \mathcal{T}_3$ are consistent.

In addition, instead of FOL theories, the previous situations can be represented by mathematical structures that have the same domain but different relations and that are models of \mathcal{T}_c .

- Abstraction from **individuals**: we can find other theories with different constant that are consistent with \mathcal{T}_c .

Or, we can find models of \mathcal{T}_c that have different domains.

175 but \mathcal{T}_c ...

- does not allow to represent both the previous situations, i.e. $\mathcal{T}_c \cup \mathcal{T}_1 \cup \mathcal{T}_3$ is inconsistent, this means that \mathcal{T}_c does not take into account *change*, i.e. it is not possible to talk about change **inside** the theory; an additional temporal/modal parameter is needed;
- does not allow to distinguish **necessary** vs. **possible** statements, i.e. if a model of the theory intuitively represents a *possible world* (a configuration of the world), then the axioms are valid in all the possible worlds by definition;
- characterizes just a specific conceptualization of the domain, more precisely, \mathcal{T}_c approximates the informal analysis A1

but ... different analyses are possible

176 DOLCE on properties

- dire qual'e' la soluzione adottata da dolce

177 Towards an empirical approach

- To provide an empirical or epistemic interpretation of this general framework. **quello di dolce, quello insomma in cui si ha la reificazione delle proprieta' + istanziazione/classificazione**
 - ▶ No strong commitment to the nature of objects.
 - ▶ **Communicability** and **inter-subjectivity** (instead than objectivity) of properties without making powerful assumptions about their conformity with 'ontological properties'.

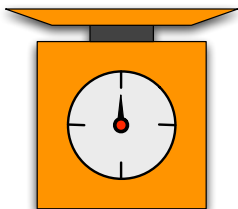
178 Giving a central role to measurement

- **Basic idea:** an object has the property of 'being 1m long' if and only if the result of its length measurement is 1m.

179 Which measurement theory?

- **Representational Measurement Theory (RMT)**
(Suppes, Krantz, Luce, and Tversky)
is one of the best known measurement theories.
- ▶ **Empirical Measurement Theory (EMT)**
(Frigerio, Giordani, and Mari)
explicitly considers the epistemic/empirical aspect of measurement.

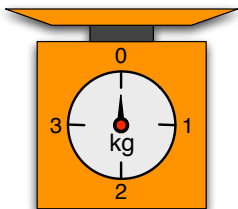
180 Measurement system: physical description



- m is the physical **support**
 - ▶ m is the scale in this case;
- $\mathcal{E} = \langle U, R_1, \dots, R_n \rangle$ is the **empirical structure**: the set of empirically discernible internal states of m and the relations between them
 - ▶ U is the set of 4 states $\{s_0, s_1, s_2, s_3\}$ that correspond to any alignment between the indicator and one notch (discrete scale);
 - ▶ R is the order established (in U) by the clockwise order of notches:

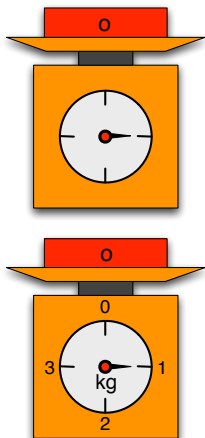
$$s_0 \prec s_1 \prec s_2 \prec s_3$$

181 Measurement system: symbolization



- $\mathcal{S} = \langle V, S_1, \dots, S_n \rangle$ is the **symbolic structure** necessary to abstract from and refer to the internal states of the support m
 - ▶ $V = \{0\text{kg}, 1\text{kg}, 2\text{kg}, 3\text{kg}\}$
 - ▶ $S: 0\text{kg} < 1\text{kg} < 2\text{kg} < 3\text{kg}$
- $\lambda: U \rightarrow V$ is the **symbolization function**
 - ▶ $\lambda(s_n) = n\text{kg}$
 - ▶ $n\text{kg} < m\text{kg}$ iff $s_n \prec s_m$

182 Measurement system: interaction



- $\kappa: O \rightarrow U$ is the **interaction function** that associates to an object $o \in O$ the internal state of the complex system $m \bullet o$
 - ▶ $\kappa(o) = s_1$, then
 - ▶ $\lambda(\kappa(o)) = 1\text{kg}$

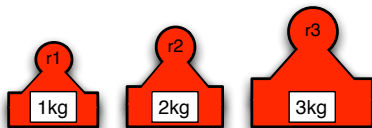
it describes as the support interacts with the environment.

183 RMT vs. EMT

- RMT conceives measurement as the building of a homomorphism from an *empirical structure* $\mathcal{O} = \langle O, R_1^O, \dots, R_n^O \rangle$ to a *numerical structure* $\mathcal{S} = \langle V, S_1, \dots, S_n \rangle$.
 - In EMT, it is the MS that *induces* (via an interaction process) a structure on objects:
 - ▶ U gives the *resolution* of the MS
$$o \approx o' \text{ iff } \kappa(o) = \kappa(o')$$
 - ▶ each R_i induces a relation on objects
$$R_i^O(o_1, \dots, o_n) \text{ iff } R_i(\kappa(o_1), \dots, \kappa(o_n))$$
- i.e. it is the MS (and the measurement procedures) that provides a specific ‘point of view’ on reality.

184 Measurement standard (mST)

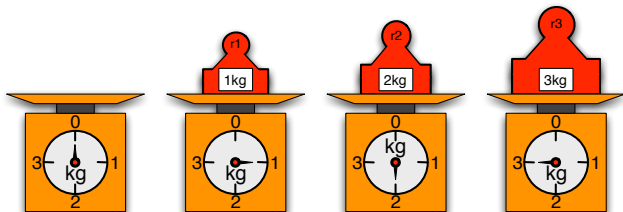
- a set R of *reference objects*: $\{r_0, r_1, r_2, r_3\}$;
(in the example we have the problem of the 'null object' r_0)
- a *symbolic structure* $\mathcal{R} = \langle M, S_1^M, \dots, S_n^M \rangle$;
 - ▶ $M = \{0\text{kg}, 1\text{kg}, 2\text{kg}, 3\text{kg}\}$;
 - ▶ $0\text{kg} < 1\text{kg} < 2\text{kg} < 3\text{kg}$;
- $\alpha: R \rightarrow M$ is a one-to-one function that conventionally assigns to each object in R a symbol in M : $\alpha(r_n) = n\text{kg}$



185 Calibration

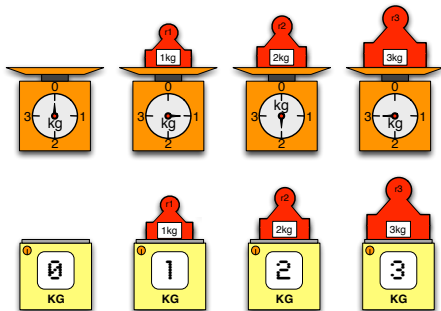
MS $\langle m, \mathcal{E}, \kappa, \mathcal{S}, \lambda \rangle$ is calibrated w.r.t mST $\langle R, \mathcal{R}, \alpha \rangle$ iff:

- ▶ $\mathcal{S} = \mathcal{R}$ (or more generally, there is a one-to-one relation between \mathcal{S} and \mathcal{R} , i.e. the MS resolves the reference objects of the mST);
- ▶ for each $r, r_1, \dots, r_n \in R$
 - ▶ $\lambda(\kappa(r)) = \alpha(r)$ and
 - ▶ $S_i(\lambda(\kappa(r_1)), \dots, \lambda(\kappa(r_n)))$ iff $S_i^M(\alpha(r_1), \dots, \alpha(r_n))$



186 Measurement framework

- A **measurement framework** is a couple $\langle s, M^* \rangle$ where s is an mST, and M^* is a set of MSs calibrated with respect to s .
- ▶ It abstracts from physical realizations of MSs and through symbolization and calibration assures *communicability* and *inter-subjectivity*.



187 Time

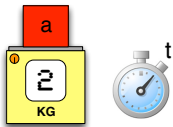
- At different times an object can interact with an MS in different ways because the object changed.

- $[t](\lambda(\kappa(a)) = s_p)$

represents the fact that m and a interacted at t with the result s_p ;

► considering λ as constant: $\kappa(a, t)$.

- At t , a has the property of 'being 2kg heavy' iff $[t](\lambda(\kappa(a)) = 2\text{kg})$, i.e. if a has been measured at t with the result 2kg.



188 The general framework in terms of MSs

Given the measurement structure $\langle O, T, S, F \rangle$:

| | |
|----------------------|--|
| Objects | $\mathbf{ob}^{\mathcal{I}} \subseteq O$ |
| Times | $\mathbf{tm}^{\mathcal{I}} \subseteq T$ |
| Regions of space i | $\mathbf{sp}_i^{\mathcal{I}} \subseteq M_i$ (the set of symbols of the mST \mathbf{s}_i in an MF of F) |
| Location | $\mathbf{L}^{\mathcal{I}} \subseteq S \times O \times T$ $\langle r, o, t \rangle \in \mathbf{L}^{\mathcal{I}}$ iff there exists an MS $\langle m, \mathcal{E}, \kappa, \mathcal{S}, \lambda \rangle \in M_i^*$ (i.e. in one measurement framework) s.t. $[t](\lambda(\kappa(o))) = r$ |

189 Measurement and realism

- The objects that interact with an MS providing the same result ($\kappa(o) = \kappa(o')$) can, but do not necessarily have to, share an *ontological/physical* property.
 - ▶ In particular an MS with a coarse resolution is probably unable to distinguish some ontological properties.
 - On the other hand, the states induced in an MS depend on the ontological properties of the objects.
 - ▶ MSs are **builted** because the classifications and the comparisons they provide allow us for (environmentally useful) **predictions**.
- (!) However, no subjective evaluations but inter-subjective measures.

190 Change of mSTs and MSs

- **mSTs can change across time**

Just because reference objects can change.

- **MSs can change across time**

Just because the supports can change

(and calibration and measurement cannot be synchronous).

191 Stable frameworks of objects

- Only by **assuming** the stability of mSTs and MSs (at least from the calibration to the measurement) the comparison between the states of $m \bullet a$ and $m \bullet b$ becomes a comparison between a and b .
- Only by **assuming** the stability of mSTs and MSs the inter-subjectivity becomes possible.
- ▶ In some sense, instead of re-identifying objects on the basis of a stable framework of properties, here we are 're-identifying properties' on the basis of a stable framework of objects.

192 Infinite regression

- **But** to empirically justify the stability of mSTs and MSs one needs to diachronically compare the supports and reference objects.
- To do that other mSTs and MSs, the stability of which, in turn, needs to be justified.

Infinite regression! (or circularity)

- One can consider the *global framework* of all mSTs and MSs, the stability of which is determined on the basis of the **mutual relationships** between the components.
- This does not detect absolute change that maintain the mutual relationships.

193 Sensory systems

- Sensory systems classify and compare distal stimuli.
 - Then, are sensory systems just MSs (as above defined)?
- ▶ Well... I don't know, but...

194 Matthen's 3 stages sensory process

- **Stimuli:** material objects and the packets of energy that they send to our sensory receptors.
- **Sensory classes:** the groups that the system makes of the stimuli, the sensory classification.
- **Sensations** (phenomenal or sensory experiences): the consciously available record of sensory classification, a label that identifies a distal stimulus as belonging to a particular class.
 - ▶ The function of sensory experience is to provide us *access* to sensory classification for purposes of reasoning.
 - ▶ Through sensations, we come to know of distal objects that have been classified a certain way (awareness of external objects).
 - ▶ Classification is available not only to consciousness.

195 Dretske: phenomenal vs. conceptual awareness

- Sensory experiences are different from knowledge, beliefs, judgments, etc.
- Two speedometers that have the same 'experience' (viz. of an axle rotation of N rpm) could give rise to different 'beliefs' (about speed, because the diameter of the connected wheels differs).
- Through learning, I can change what I believe when I see k , but I can't much change the way k looks (phenomenally) to me (...) We can, through learning, change our calibration.

196 Pylyshyn: things

“[T]he core of the connection between mind and world lies the question of how vision is able to select or pick out or refer to individual *things* in a scene – tokens or individuals rather than types”

197 The 3D / 4D debate

- Three- vs. four-dimensionalism.
 - ▶ Do all entities have temporal parts?
 - ▶ Objects / events, endurants / perdurants, continuants / occurents.
- Co-localization, multiplicationism and identity criteria.
 - ▶ Mereology: things that have the same parts are identical.
 - ▶ Does a given spatio-temporal worm identify a single entity? (strong four-dimensionalism)
- Identity across time.
 - ▶ Is Tibbles the cat identical to Tib?

198 Puzzles about change through time

- According to Sally Haslanger these puzzles rely on general conditions that, when integrally accepted, generate a contradiction:
 1. Objects persist through change.
 2. The properties involved in a change are incompatible.
 3. Nothing can have incompatible properties.
 4. The object before the change is one and the same object after the change.
 5. The object undergoing the change is itself the proper subject of the properties involved in the change.
- **Perdurantism** (four-dimensionalism) rejects condition 5.
- **Endurantism** (three-dimensionalism) rejects condition 2.

199 ...for example

- A rose r persists through a change from 'red' (R) to 'brown' (B), two incompatible properties, i.e. $\neg\exists x(R(x) \wedge B(x))$.
- Accepting 1-5, $R(r) \wedge B(r)$ holds leading to a contradiction.

Perdurantism: at any instant objects are only **partially present**,

- at each time, a different temporal part exists, $r\text{-at-}t \neq r\text{-at-}t'$;
- r is red at t because it has a *temporal part* ($r\text{-at-}t$) that is red at t ;
- $R(r\text{-at-}t) \wedge B(r\text{-at-}t')$ does not lead to any contradiction.

Endurantism: at any instant objects are **wholly present** but

- 'being red' and 'being brown' need to be *temporally qualified*;
- 'being red' and 'being brown' are incompatible only if stated at the

same time (about the same object);

- the fact that r is red-at- t and it is brown-at- t' does not lead to any contradiction.

200 Partially and wholly present

- The distinction between perdurantism and endurantism is often stated (informally) in terms of the notions of being partially/wholly present.
 - ▶ **Being partially present** has been quite precisely characterized.
 - ▶ **Being wholly present** is still quite obscure.
- Therefore the formal distinction between perdurantism and endurantism often reduces to different positions on *parthood*:
 - ▶ endurantists claim that a primitive temporally qualified parthood (**temporary parthood**) is required;
 - ▶ perdurantists assume an atemporal parthood (**parthood simpliciter**) and they define “ x is part of y at t ” as “ x -at- t is part of y -at- t ”.

201 Perdurantism stated (using temporary parthood)

- Theodore Sider introduced a formal characterization of perdurantism based on **temporary parthood**, in this way:
 - ▶ *endurantists* can better understand the perdurantist view because it is characterized in terms of temporary parthood;
 - ▶ *perdurantists* can accept it standardly analyzing “ x is part of y at t ” as “ x -at- t is part of y -at- t ”.
- This analysis of temporal parthood is not accepted by endurantists because it presuppose the existence of temporal parts that endurantists refuse (at least in general).
- Therefore, the distinction between endurantists and perdurantists is basically reduced to the acceptance of temporal parts.

202 My main contributions

1. A formal analysis of the interconnections between theories of parthood and theories of temporary parthood and of how these interconnections depend on **existential conditions**.
2. A definition of temporary parthood in terms of parthood simpliciter that does not rely on temporal parts.

I will prove that, via this definition, the axioms for temporary parthood can be ‘recovered’ in a theory based on parthood simpliciter *without* assuming the existence of temporal parts.

In this way *endurantists* do not necessarily need to consider *temporary parthood* as primitive, they can start from parthood simpliciter analyzing “*x* is part of *y*” as *constant parthood*, i.e. “*x* is part of *y* at every time at which it (*x*) exists”.

(!) I do **not** provide/have a characterization of endurantism.

203 Are these contributions relevant for common-sense?

- “Approaches to temporal reasoning used by the common-sense community (e.g., all formalisms for reasoning about action and time) are endurantist.”
- Therefore,
 - ▶ why study perdurantism?
 - ▶ why study the interconnections between theories of parthood simpliciter and theories of temporary parthood?
- I don't have a definite answer, only few hints that, I hope, could be useful for the commonsense community.

204 Hint 1

- Both parthood simpliciter and temporary parthood are very general and foundational notions that can be used in order to formalize different domains;
e.g., endurantists often use parthood simpliciter for events or histories, therefore understanding how these notions are linked is relevant for endurantists too.
- In a perspective of integration with other systems that can be based on different ontological assumptions, the links help in understanding what perdurantists and endurantists can exchange.
“so many researchers develop their own theories to solve a particular problem, even when similar theories already exist. The result is a large number of theories, mostly incomparable, each suited to some problem, but none suited to a broad class of problems.” [E. Davis, L.

Morgenstern, 'Progress in formal commonsense reasoning', 2004]

205 Hint 2

- I think that the initial puzzle about change is a ‘commonsense’ puzzle.
- The perdurantist solution is an alternative to the endurantist one. The analysis of pros and cons of these solutions is interesting to understand their adequateness to model specific domains.
- Is the perdurantist solution incompatible with commonsense?
- In my understanding, commonsense theories need to consider mesoscopic entities, to deal with qualitative information, to be (using the word of Jerry Hobbs) “close to the intuitive theories of the world”.
- Perdurantism does not presupposes a fine-grained level of detail nor quantitative knowledge.

206 Hint 3

- Is perdurantism a **non**-intuitive theory of the world?
- But, what is an “intuitive theory of the world”?
- Often one refers to **natural language**, to the theories “we seem to presuppose when we talk about the world, and less like those of real physics”
“one can assume a more ‘intuitive’ ontology, one that is isomorphic to the language we use to talk about the world.” [Jerry Hobbs, Introduction of ‘Formal Theories of the Commonsense World’]
- Perdurantism has been used as an ontological foundation to the semantics of the natural language, and this semantics solves a number of well-known semantic phenomena.
- From a different perspective, the perdurantist view is now used

in applications, advocating its adequateness, conceptual simplicity and practical advantages for representing dynamic environments.

207 Hint 4

- Let us suppose that P and Q are intrinsic properties.
- (Strong) Perdurantism provides an 'ontological basis' for formal expressions like $P(x, t)$: it is the temporal slice of x at t that has the property P , i.e., $P(x\text{-at-}t)$.

Therefore, it ontologically explains change: x changes because it has temporal parts with different properties, $P(x\text{-at-}t) \wedge Q(x\text{-at-}t')$.

- Endurantists write $P(x, t) \wedge Q(x, t')$ (or use a temporal logic) without explaining what happened to x in order to change from P to Q .
- David Lewis noticed: either endurantists assume that P and Q are relational properties or an alternative explanation is required.

- Conceiving change as *trope* substitution is an alternative ontological explanation compatible with endurantism but maybe not so commonsensical.

208 Hint 5

- The perdurantist idea of reducing predication at a time to the predication on the temporal slice is already present in
K. Forbus “Qualitative Process Theory”, and
P. Hayes “Ontology For Liquids”.
- They both talk about ‘histories of objects’ vs. objects, but the distinction between the two kinds of entities is not clear (at least to me).

209 Hint 5: Forbus, p.104

- A *slice* of a history denotes a piece of an object's history at a particular time. We denote a slice of an individual i at a time t by $\text{at}(i, t)$.

If we let all functions, predicates, and relations that apply to objects to apply to slices as well, with functions that map from objects to quantities map from slices to values, then we could be rid of T and M and just talk in terms of slices.

Instead of $(T \text{ Aligned}(P_1) t_0)$ we could write $\text{Aligned}(\text{at}(P_1, t_0))$

For clarity of exposition, however, we continue to use T and M .

- (!) If I understand correctly, P_1 is an object, while T and M are two modal operators: $(T \text{ Aligned}(P_1) t_0)$ means " P_1 is aligned at t_0 ".

210 Hint 5: Hayes, p.93

- A physical object is a three-dimensional entity which has an associated history representing the life-span of the object: a slice of this history (which we call the *life* of the object), *is* the object at a given time.

A special case which will be useful later is a history during which non change takes place at all. We will call this an *enduring*. Given a three-dimensional entity o , and a time-interval I , $endure(o, I)$ is defined by the following:

$$\begin{aligned} when(endure(o, I)) &= I \\ \forall t \in I. endure(o, I)@t &= \langle o, I \rangle \end{aligned}$$

(!) $endure(o, I)$ is an history and $h@t$ is the slice of h at t , but what

is (the ontological status of) $\langle o, I \rangle$?

211 Relevant notions

Parthood simpliciter

$EXxt$ “ x exists at t ”;

Pxy “ x is part of y ”.

Temporary Parthood

$EXxt$ “ x exists at t ”;

$tPxyt$ “ x is part of y at t ”.

Definitions on the basis of P:

$$\mathbf{d1} \quad Oxy \triangleq \exists z(Pzx \wedge Pzy)$$

$$\mathbf{d2} \quad TPxyt \triangleq EXxt \wedge EXyt \wedge \neg \exists t'(EXxt' \wedge t' \neq t) \wedge \\ Pxy \wedge \forall z(Pzy \wedge EXzt \rightarrow Ozx)$$

$$\mathbf{d3} \quad tPxyt \triangleq \exists zw(TPzxt \wedge TPwyt \wedge Pzw)$$

Definitions on the basis of tP:

$$\mathbf{d4} \quad tOxyt \triangleq \exists z(tPzxt \wedge tPzyt)$$

$$\mathbf{d5} \quad tTPxyt \triangleq \neg \exists t'(EXxt' \wedge t' \neq t) \wedge tPxyt \wedge \forall z(tPzyt \rightarrow tOzxt)$$

$$\mathbf{d6} \quad Pxy \triangleq \forall t(EXxt \rightarrow tPxyt)$$

212 The theories \mathcal{T}_{tP} and \mathcal{T}_{P}

\mathcal{T}_{tP} : **temporary parthood** (Sider)

$$\mathbf{a1} \quad \exists t(\text{EX}xt)$$

$$\mathbf{a2} \quad \text{tP}xyt \rightarrow \text{EX}xt \wedge \text{EX}yt$$

$$\mathbf{a3} \quad \text{EX}xt \rightarrow \text{tP}xxt$$

$$\mathbf{a4} \quad \text{tP}xyt \wedge \text{tP}yzt \rightarrow \text{tP}xzt$$

$$\mathbf{a5} \quad \text{EX}xt \wedge \text{EX}yt \wedge \neg \text{tP}xyt \rightarrow \\ \exists z(\text{tP}zxt \wedge \neg \text{tO}zyt)$$

$$\mathbf{pd} \quad \text{EX}xt \rightarrow \exists y(\text{tTP}yxt)$$

\mathcal{T}_{P} : **parthood simpliciter**

$$(\mathbf{a1}) \quad \exists t(\text{EX}xt)$$

$$\mathbf{a6} \quad \text{P}xx$$

$$\mathbf{a7} \quad \text{P}xy \wedge \text{P}yx \rightarrow x = y$$

$$\mathbf{a8} \quad \text{P}xy \wedge \text{P}yz \rightarrow \text{P}xz$$

$$\mathbf{a9} \quad \neg \text{P}xy \rightarrow \exists z(\text{P}zx \wedge \neg \text{O}zy)$$

$$\mathbf{a10} \quad \text{P}xy \wedge \text{EX}xt \rightarrow \text{EX}yt$$

$$\mathbf{pdn} \quad \text{EX}xt \rightarrow \exists y(\text{TP}yxt)$$

213 \mathcal{T}_P is strictly stronger than \mathcal{T}_{tP}

$$\mathbf{t1} \quad \mathcal{T}_{tP} \not\models \mathbf{tTP}xyt \wedge \mathbf{tTP}zyt \rightarrow x = z$$

$$\mathbf{t2} \quad \mathcal{T}_{tP} \not\models \forall t(\mathbf{EX}xt \rightarrow \mathbf{tP}xyt) \wedge \forall t(\mathbf{EX}yt \rightarrow \mathbf{tP}yxt) \rightarrow x = y$$

$$\mathbf{t6} \quad \mathcal{T}_P \vdash_{(d3)} \mathcal{T}_{tP}$$

$$\mathbf{t7} \quad \mathcal{T}_P \vdash_{(d3)} \mathbf{tTP}yxt \wedge \mathbf{tTP}yzt \rightarrow y = z$$

$$\mathbf{t8} \quad \mathcal{T}_P \vdash_{(d3)} \forall t(\mathbf{EX}xt \rightarrow \mathbf{tP}xyt) \wedge \forall t(\mathbf{EX}yt \rightarrow \mathbf{tP}yxt) \rightarrow x = y$$

$$(d3) \quad \mathbf{tP}xyt \triangleq \exists zw(\mathbf{TP}zxt \wedge \mathbf{TP}wyt \wedge \mathbf{P}zw)$$

(!) In \mathcal{T}_{tP} , the temporal part at a time is not unique and two different entities can be one part of the other during their whole life.

214 $\mathcal{T}_P \setminus \{(a7)\}$ is equivalent to \mathcal{T}_{tP} via (d3)&(d6)

\mathcal{T}_P is strictly stronger than \mathcal{T}_{tP} because of the antisymmetry of P :

t9 $\mathcal{T}_P \setminus \{(a8)\} \not\vdash_{(d3)} (a4)$ (a8): transitivity of P

(a4): transitivity of tP

t10 $\mathcal{T}_P \setminus \{(a9)\} \not\vdash_{(d3)} (a4)$ (a9): extensionality of P

t11 $\mathcal{T}_P \setminus \{(a10)\} \not\vdash_{(d3)} (a4)$ (a10): temporal monotonicity of P

t12 $\mathcal{T}_P \setminus \{(a7)\} \vdash_{(d3)} \mathcal{T}_{tP}$ (a7): antisymmetry of P

t14 $\mathcal{T}_P \setminus \{(a7)\} \not\vdash_{(d3)} \mathbf{tTP}yxt \wedge \mathbf{tTP}zxt \rightarrow y = z$

t15 $\mathcal{T}_P \setminus \{(a7)\} \not\vdash_{(d3)} \forall t(\mathbf{EX}xt \rightarrow \mathbf{tP}xyt) \wedge \forall t(\mathbf{EX}yt \rightarrow \mathbf{tP}xyt) \rightarrow x = y$

(d3) $\mathbf{tP}xyt \triangleq \exists zw(\mathbf{TP}zxt \wedge \mathbf{TP}wyt \wedge \mathbf{P}zw)$

t16 $\mathcal{T}_{tP} \vdash_{(d6)} \mathcal{T}_P \setminus \{(a7)\}$

(d6) $\mathbf{P}xy \triangleq \forall t(\mathbf{EX}xt \rightarrow \mathbf{tP}xyt)$

215 \mathcal{T}_P is equivalent to $\mathcal{T}_{tP} \cup \{(a11)\}$ via (d3)&(d6)

\mathcal{T}_{tP} can be strengthened via (a11) (that directly corresponds to the antisymmetry of P), to achieve a theory equivalent to \mathcal{T}_P :

$$\mathbf{a11} \quad \forall t(\mathbf{EX}xt \rightarrow \mathbf{tP}xyt) \wedge \forall t(\mathbf{EX}yt \rightarrow \mathbf{tP}yxt) \rightarrow x = y$$

216 Comments on the two equivalences

- The main difference between \mathcal{T}_{tP} and \mathcal{T}_P concerns the uniqueness of the temporal parts and the acceptance of *coincident* objects (objects that are one part the other during their whole life).
- I don't know if Sider was aware that in \mathcal{T}_{tP} the uniqueness of temporal part does not hold (perdurantists often start from P).
- \mathcal{T}_{tP} shows that, even though we assume temporal parts, coincident entities can differ, e.g. the statue and the the clay can be different even though they are one part of the other during their whole life.
- This is compatible with the endurantist view that accept coincident objects that are different because of non mereological properties.
- \mathcal{T}_P is a stronger version of perdurantism that, identifying coincidence with identity, tends to reduce differences among objects to

mereological ones (in particular spatio-temporal ones).

217 Avoiding temporal parts

- The previous equivalences rely on the existence of temporal parts:

t17 $\mathcal{T}_P \setminus \{(pdn)\} \not\vdash_{(d3)} (a3)$ (a3): reflexivity of tP

t18 $\mathcal{T}_{tP} \cup \{(a11)\} \setminus \{(pd)\} \not\vdash_{(d6)} (a9)$ (a9): extensionality of P

endurantists cannot accept (d3) as a definition of tP in terms of P .

- My definition is based on existential conditions weaker than the existence of temporal parts. I consider an *extensional closure mereology* $\mathcal{T}_P^c = \mathcal{T}_P \cup \{(a12), (a13)\}$ extended by (a14).

d7 $SUMsxy \triangleq \forall z (Ozs \leftrightarrow Ozx \vee Ozy)$

d8 $DIFdxy \triangleq \forall z (Pzd \leftrightarrow Pzx \wedge \neg Ozy)$

a12 $\exists s (SUMsxy)$

a13 $\neg Pxy \rightarrow \exists d (DIFdxy)$

a14 $DIFdxy \wedge EXxt \wedge \neg EXyt \rightarrow EXdt$

t21 $\text{SUM}_{sxy} \wedge \text{EX}_{st} \rightarrow (\text{EX}_{xt} \vee \text{EX}_{yt})$

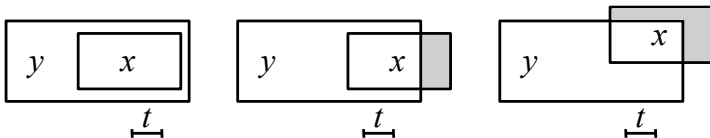
218 An alternative definition

$$\mathbf{d9} \quad \mathbf{tPx}y\mathbf{t} \triangleq \mathbf{EX}x\mathbf{t} \wedge \mathbf{EX}y\mathbf{t} \wedge (\mathbf{P}x\mathbf{y} \vee \exists d(\mathbf{DIF}dxy \wedge \neg \mathbf{EX}d\mathbf{t}))$$

- both x and y exists at t ;
- x is part of y at every time at which it exists (and therefore, in particular, at t)

OR

if x is part of y at t but not during its whole life, then the difference between x and y exists but it is not present at t (otherwise some parts of x that exist at t are not part of y).



219 $\mathcal{T}_P^c \cup \{(a14)\}$ is strictly stronger than $\mathcal{T}_{tP} \cup \{(a11)\} \setminus \{(pd)\}$

- **t22** $\mathcal{T}_P^c \cup \{(a14)\} \vdash_{(d9)} \mathcal{T}_{tP} \cup \{(a11)\} \setminus \{(pd)\}$

but (pd) is essential to prove the extensionality of P

(t18) $\mathcal{T}_{tP} \cup \{(a11)\} \setminus \{(pd)\} \not\vdash_{(d6)} (a9)$ (a9): extensionality of P

- $\mathcal{T}_P^c \cup \{(a14)\}$ does not imply the existence of temporal parts

t23 $\mathcal{T}_P^c \cup \{(a14)\} \not\vdash (pdn)$

t24 $\mathcal{T}_P^c \cup \{(a14)\} \not\vdash_{(d9)} (pd)$

- In the paper I propose an extension of $\mathcal{T}_{tP} \cup \{(a11)\} \setminus \{(pd)\}$ that is enough to recover (a9) but still is too weak to recover $\mathcal{T}_P^c \cup \{(a14)\}$.
- Adding to $\mathcal{T}_{tP}^n \cup \{(a11)\}$ the analogue of axioms (a12) and (a13)

(existence of sums and differences) can be enough but the proof of equivalence is not trivial.

220 Events

- Anything that happens, takes place, or occurs.
- Examples: births, marriages, fallings, football games, etc.
- Common-sense: we perceive, plan, speak and discuss about events, therefore there are events just as there are objects.
- Philosophy:
 - ▶ are events just *façon de parler* or do they have an ontological status?
 - ▶ are events reducible to objects, properties, change, etc. or are they a genuine ontological category?
- **terminological clarification:** according to simons, *occurrents* include events, processes and states.

- **I motivate events from the representational point of view**

221 Introducing events 1

- How to represent in FOL all the following sentences involving a verb (to butter) with a variable number of arguments?
 - ▶ Jones slowly buttered a piece of toast with a knife in the bathroom at midnight.
 - ▶ Jones buttered a piece of toast in the bathroom at midnight.
 - ▶ Jones buttered a piece of toast in the bathroom.
 - ▶ Jones buttered a piece of toast at midnight.
 - ▶ Jones slowly buttered a piece of toast.
 - ▶ Jones buttered a piece of toast.
 - ▶ Jones buttered something with a knife.
 - ▶ Jones did something with a knife in the bathroom at midnight.

222 Introducing events 2

- By using a plurality of predicates *Butter* with different arity or different kinds of arguments:
 - ▶ Jones buttered a piece of toast in the bathroom at midnight.
 $\text{Butter}_1(\textit{Jones}, \textit{toast}, \textit{bathroom}, \textit{midnight})$
 - ▶ Jones buttered a piece of toast in the bathroom.
 $\text{Butter}_2(\textit{Jones}, \textit{toast}, \textit{bathroom})$
 - ▶ Jones buttered a piece of toast at midnight.
 $\text{Butter}_3(\textit{Jones}, \textit{toast}, \textit{midnight})$
 - ▶ Jones slowly buttered a piece of toast.
 $\text{Butter}_4(\textit{Jones}, \textit{slowly}, \textit{toast})$
 - ▶ Jones buttered something with a knife.
 $\exists x(\text{Butter}_5(\textit{Jones}, x, \textit{knife}))$

223 Introducing events 3

- How is it possible to link the different Butter_n predicates?
- Additional axioms with existential conditions are necessary , e.g.:
 - ▶ $\text{Butter}_2(\text{Jones}, \text{toast}, \text{bathroom})$
 - ▶ $\text{Butter}_3(\text{Jones}, \text{toast}, \text{midnight})$
 - ▶ $\text{Butter}_4(\text{Jones}, \text{slowly}, \text{toast})$
 - $\text{Butter}_2(x, y, z) \rightarrow \exists w(\text{Butter}_3(x, y, w))$
 - $\text{Butter}_3(x, y, z) \rightarrow \exists w(\text{Butter}_2(x, y, w))$
 - $\text{Butter}_3(x, y, z) \rightarrow \exists w(\text{Butter}_4(x, z, y))$
 - ...

224 Introducing events 4

- Note that, by assuming a fixed reference to 'Jones' and 'midnight' (of a specific day), one can convert the sentence (see Quine)
 - ▶ Jones slowly buttered a piece of toast with a knife in the bathroom at midnight.

into a *conjunction* of four sentences

- ▶ Jones buttered slowly at midnight **and**
Jones buttered a piece of toast at midnight **and**
Jones buttered with a knife at midnight **and**
Jones buttered in the bathroom at midnight.
- However, to split 'buttered slowly' one needs to find an additional fixed reference.

225 Introducing events 5

- In his seminal paper [Davidson, 1967] Davidson refers to events and all the parameters are introduced by relations with events:
 - ▶ Jones slowly buttered a piece of toast with a knife in the bathroom at midnight.
 $\text{Butter}(e) \wedge \text{Slow}(e) \wedge \text{Agent}(e, \text{John}) \wedge \text{Patient}(e, \text{toast}) \wedge \text{Time}(e, \text{midnight}) \wedge \text{Place}(e, \text{bathroom}) \wedge \text{Instrument}(e, \text{knife})$
 - ▶ Jones buttered a piece of toast in the bathroom at midnight.
 $\text{Butter}(e) \wedge \text{Agent}(e, \text{John}) \wedge \text{Patient}(e, \text{toast}) \wedge \text{Time}(e, \text{midnight}) \wedge \text{Place}(e, \text{bathroom})$
- Only one Butter predicate.
- The first formula implies the second one.

226 Introducing events 6

- Using events it is also possible to represent the last sentence in a direct way.

► Jones did something with a knife in the bathroom at midnight.

$\exists e(\text{Event}(e) \wedge \text{Agent}(e, \text{John}) \wedge$
 $\text{Time}(e, \text{midnight}) \wedge \text{Place}(e, \text{bathroom}))$

227 Events

- Further advantages
 - ▶ Event anaphora: It happened at midnight
event nominalization: The buttering was slow
 - ▶ Quantification: In every burning, oxygen is consumed and Ann burned the wood, therefore Oxygen was consumed.
 - ▶ Predication over events: I enjoyed reading the book, I saw you enter, I heard the explosion
- [Moens and Steedman, 1988] show that tenses can be more systematically accounted for using events, assuming these have a complex structure (preparatory process, culmination event, conseq. state)
- But: no widely accepted ontologies of events...
sarebbe bello far vedere come anche qui si possono introdurre

dei discorsi modali per evitare la reificazione, tipo 'adverbial modifiers' di clark, cit. p362, simons, oxfordhand

- **la prima lezione si potrebbe proprio fare qualche slides che spiega in generale il discorso tra logica modale e reificazioni in logica del primo ordine, dopo avere detto che assumiamo un committment esistenziale debole su cio' che mettiamo nel dominio di quantificazione – VEDI SE PRENDERE QUALCHE COSA DA ARTICOLO DI ROBERT E LAURE PER FOIS06**

228 Events as truthmakers

- vedi p.363 Simons/oxford hand
- What makes true the sentence 'John kissed Mary' is any event which is a (past) kissing of Mary by John.
- **qui forse link con “a world of states of affair” di Armstrong**

229 Events

- Let us assume that we want to talk of events, we want to introduce events in our domain of quantification
- are events a basic kind or are they derivable or constructible in terms of other more basic kinds? (simons, p.369)
- **questo e' anche forse una cosa metodologica che andrebbe detta all'inizio: in alcuni casi dal p.to di vista rappresentazione, e' forse piu' conveniente restare piu' generali partire da un numero di predicati primitivi piu' esteso e far vedere quali ipotesi, quali assiomi, siano necessari per ridurre tale primitiva definendola in termini di altre primitive**

230 Eventists' views

- ▶ **Quine**: events and objects are both 4d entities
- ▶ **Lewis**: properties of spatio-temporal regions, i.e. classes of individuals from various worlds.
- ▶ **Kim**: events are exemplifications of properties by substances at a given time (gerundive nominalization of '*s* has *P* at *t*') [vedi controes. events, p.xxiv e seguenti]
- ▶ **Bennett** (1988): events as tropes, i.e. instances of properties located at spatio-temporal regions (see events p.xix for the qualification of what properties)
- ▶ **Lombard** (1986) is similar to Kim, but events involve changes: 'movements' by physical objects through some portion of a quality space during a stretch of time. (**but some events are the creation or annihilation of objects, then what changes in these cases?**)

Similarly for the cases of states. Case of Cambridge change and intrinsic properties.)

231 Jaegwon Kim

- Definition:
 - ▶ an event is the exemplification by an object (several objects) of a property (relation) at a time;
 - ▶ noted by $[x, P, t]$ where x is the constitutive object, P is the constitutive property x exemplifies and t is a time.
 - if John shouts, $x = \text{John}$, $P = \text{shouting}$, t is the time of shout;
 - the collision of the Titanic with the iceberg, then $x_1 = \text{Titanic}$, $x_2 = \text{the iceberg}$, $R = \text{colliding with}$.
- This corresponds to assuming three primitives 'is the constitutive property of', 'is the constitutive property of', and 'is the time of the occurrence of'. **quindi e' come avere gli eventi nel dominio che sono collegati a tre entita' diverse, e ho chiaramente bisogno anche delle proprieta', e poi ci metto le due condizioni di es-**

istenza e di indentita'

- An event has therefore a complex structure and it has three unique constituents.
- Therefore the theory is not reductive with respect to events, they cannot be reduced to object, properties, and times. The theory just relates the nature of events to the one of objects, properties and times.
- Two basic principles in the theory: existential condition and identity condition.

232 Kim 2 (existential condition)

- Existential condition:
 - ▶ $[x, P, t]$ exists **iff** x has P at t
 - an event $[x, P, t]$ is not just a triple (that exists always when its component exist) but it *supervenies* its essential constituents.
 - ▶ **la nozione di proprieta' di Kim e' piuttosto strana, non sono affatto sicuro sarebbe un universale di cui x e' un'istanza (forse e' esemplificazione che e' diverso da istanziazione), in che senso ad es. falling e' completamente present in x , o in che senso walking e' completamente presente in John? cioe' qui ho un po' di casino rispetto alla teoria dei tropi perche' c'e' il cambiamento in atto che nei tropi non c'e', il falling e' forse una specie di meta-tropo relazionale tra tropi**

233 Kim 3 (identity condition)

- Identity condition:

- ▶ $[x, P, t] = [y, Q, t']$ **iff** $x = y$ and $P = Q$ and $t = t'$
- Goliath \neq Lumpl \Rightarrow *Goliath's rotating* \neq *Lumpl's rotating*.
- 'waking' \neq 'waking abruptly' \Rightarrow *John's waking* \neq *John's abrupt waking* (the second property is a specialization of the first one);
- Kim answer: *John's abrupt waking* is *John's waking* with the property of 'being abrupt'
- what identity between properties (extensional, intensional, ...)?

234 Kim: properties

- which properties can be the constitutive property of an event?
(e.g. abstract properties that apply to all thing at all time, self-identity and tautologies, negation of properties, conjunction of properties, ecc.)
- states are included
- Cambridge events (e.g. $P =$ 'becoming a widow')
- identity of properties
- modifiers of properties (e.g. walking slowly vs. walking), but properties of events are distinct from constitutive properties, i.e. properties of the constitutive object

235 Kim vs. Davidson 1

- Jones buttered a piece of toast at midnight.
 - ▶ **Davidson** (where Butter is here a unary property):
 $\text{Butter}(e) \wedge \text{Agent}(e, \text{John}) \wedge \text{Patient}(e, \text{toast}) \wedge \text{Time}(e, \text{midnight})$
 - ▶ **Kim** (where Butter is here a binary property):
 $[\langle \text{John}, \text{toast} \rangle, \text{Butter}, \text{midnight}]$

236 Kim vs. Davidson 2

- Jones slowly buttered a piece of toast with a knife at midnight.

- ▶ **Davidson:**

$\text{Butter}(e) \wedge \text{Slow}(e) \wedge \text{Agent}(e, \text{John}) \wedge \text{Patient}(e, \text{toast}) \wedge$
 $\text{Time}(e, \text{midnight}) \wedge \text{Instrument}(e, \text{knife})$

- ▶ **Kim** (option 1):

$[\langle \text{John}, \text{toast} \rangle, \text{Butter}, \text{midnight}] \neq$

$[\langle \text{John}, \text{toast} \rangle, \text{SlowButter}, \text{midnight}] \neq$

$[\langle \text{John}, \text{toast} \rangle, \text{WithKnifeButter}, \text{midnight}]$

- 'Slowly' and 'with a knife' do not modify the constitutive property, therefore one has a duplication of events.
- However, to count events is similar to count objects and believing in the calculus of individuals, included in a table there are indefinitely many tables each of which is a proper part this table.

237 Kim vs. Davidson 3

- Jones slowly buttered a piece of toast with a knife at midnight.

- ▶ **Davidson:**

$\text{Butter}(e) \wedge \text{Slow}(e) \wedge \text{Agent}(e, \text{John}) \wedge \text{Patient}(e, \text{toast}) \wedge$
 $\text{Time}(e, \text{midnight}) \wedge \text{Instrument}(e, \text{knife})$

- ▶ **Kim** (option 2):

$\text{Slow}([\langle \text{John}, \text{toast} \rangle, \text{Butter}, \text{midnight}]) \wedge$
 $\text{WithKnife}([\langle \text{John}, \text{toast} \rangle, \text{Butter}, \text{midnight}])$

- ‘Slowly’ and ‘with a knife’ do not modify the constitutive property Butter, instead they are properties of the generic events that exemplify the property Butter.
- WithKnife and WithStick are different properties, therefore one loses the fact that both knives and sticks are instruments.

238 Jonathan Bennett 1

- Definition:

- ▶ events are a special case of *tropes*: an event is the *instantiation* of a property by (something in) a *zone* (or a thing at a time).
- Zones include 4d regions, planes, lines, and points.
- “[W]herever a space-occupying thing x has property P at time t , that is because at a deeper metaphysical level the zone defined by x at t has a corresponding property P^* .” (p.88 libro Bennett):
 1. To be an object in a given region of space is for that region to be *thus* rather than *so*, i.e., in 4d, the notion of object is analyzed in terms of attributes of zones.
 2. Criteria to collect zones of one object are based on causality: the greater causal contribution comes from the thing itself.

- Weak metaphysical position: events are *supervenient* on substances and properties (unless tropes are more fundamental than substances and properties).
- Events are not at the same level of substances and properties.

239 Bennett vs. Quine vs. Kim

- Quine: an event is the (material) content of a zone.
- Bennett, p.104 libro dice, anche se dice che non sa se Quine sarebbe d'accordo: One could say that Quine's events are also property instances, the property (...) being the conjunction, so to speak, of all the properties that are instantiated at the zone.
- Bennett p.104 libro: Where Kim's metaphysic maps events onto s - P - t triples, Quine's maps them onto s - t pairs. Or, if we generalize [**specialise ?**] each a little, Kim maps events onto zone-property pairs, while Quine maps then onto zones. [**qui sto assumendo una sorta di ontologia 4d**] Since a Quinean event is constituted by all the properties that are instantiated at the zone, it is uniquely determined by the zone, with no need to mention properties at all.

240 Bennett: co-located events

- Because events are tropes, then the same zone can in principle instantiate different properties, therefore spatiotemporally coinciding events can exist.
- According to the structure of properties they instantiate, it is then possible to fuse or fission zonally coinciding events.
- Fission allows for *abstraction* while fission for *concreteness*. **forse si puo' mettere un link a determinable vs. determinate**
- **Quine**: unifier approach, events cannot be abstract (in some sense, only the tropes relative to the conjunction of all the properties a zone instantiates exist)
- **Kim**: more liberal approach even though he explicitly claims that not all the properties 'generate' an event.

241 Bennett and tropes

- The fall that stone s underwent at time t is one particular instance—namely the by- s -at- t instance—of the property '*being falling*'.
- (????) In terms of trope theory, the event is the 'being falling of s ' [Bennett says the fall of s] that exists at t , i.e. normally is the time at which the trope exists that makes evident the time at which s has the property, i.e. change is trope substitution, tropes do not survive change. **forse si salva per il fatto che lui ha le zones? e quindi e' la zona 4d the e' istanza di falling ed ha il tempo dentro di essa gia', la cosa e' molto piu' difficile con gli oggetti**
- Bennett has a much less restrict notion of property than universalists. For example, the conjunction of two properties is still a property that generate a *complex* trope, therefore, tropes seem to have a structure that reflect the structure of properties.

242 Objects vs. Events in 4d

- **l'approccio di bennett e' interessante perche' e' anche un altro modo per vedere la differenza tra oggetti ed eventi in una teoria 4d. Gli eventi sono tropi, gli oggetti non lo sono anche se Quine direbbe: perche' mi serve il tropo? Mi basta la zona**
- **in ogni caso Bennett prospetta anche un approccio in cui una zona non necessariamente individua un oggetto fisico, solo certe zone sono un oggetto fisico (o piu' genericamente, le condizioni di unita' degli oggetti sono diverse da quelle degli eventi), qui comunque ci sarebbe il problema di differenziare un oggetto dalla sua history/life**
- Quinton: the only difference between events and physical objects is that two events can, while two physical objects cannot, fully occupy a zone.

243 Cleland

- In reality, there exist determinable properties (*phases*) that are constituted by *basic* determinate properties (*states*), i.e. properties that do not admit any further differentiation and that cannot be analyzed in terms of other properties (p.234, **vedi come le chiamiamo noi, ma l'essere non analizzabili e' nuovo in qualche maniera in quanto 100gradi non e' basic perche' e' analizzabile in termini di kinetic energy**).
- A *concrete phase* is an instance of a phase (to be intended as particularized properties / tropes).

244 Cleland: individuation of concrete phases

- It is not obvious that every case of a different instance of the same property always involves a difference in spatial and/or temporal region (therefore a difference in physical objects), then concrete phases cannot be individuated in terms of properties, spatiotemporal region, and physical objects.
- Cleland then assume that the individuality of concrete phases is primitive, they are 'nakedly' numerically distinct, they are basic individuals (she avoids to enter into the discussion about the reduction of objects to (classes of) concrete phases).

245 Cleland: concrete changes

- A concrete phase that is an instance of property P survive the going in and out of existence of instances of *states* (determinate properties) that are specializations of P .
- A *concrete change* R is a pair $\langle x, y \rangle$ such that x is the exemplification of a state s by a concrete phase CP at a time t and y is the exemplification of a state s' by CP at a time t' , where (i) t precedes t' and (ii) $s \neq s'$.
- An *event* is a concrete change, i.e. formally, $\langle [CP, s, t], [CP, s', t'] \rangle$.
dove '[' denota l'esemplificazione – le condizioni di identità sono quelle di Kim adattate ora alla coppia

246 Cleland vs. Kim vs. Lombard vs. Bennett

- Events do not depend on physical objects but on concrete phases (which may or may not involve physical objects).
- Different phases can be spatiotemporally co-located, therefore, differently from Lemmon, different events can be co-located.
- W.r.t. Bennett, here it is possible to account for events that are not necessarily linked to space (or physical objects) because with concrete phases changes are possible even in absence of spatial locations.

247 Cleland: dynamical system theory

- Dynamical systems are represented as vectorfields defined on state spaces.
- A *one dimensional state space* (e.g. temperature) corresponds to a phase P and each state in the space corresponds to a determinate property that comes under P .
- An axis (dimension) in a *multi dimensional state space* (e.g. color) corresponds to a phase and the states correspond to a n -tuples (one for each phase) of determinate properties.
- In a state space, changes are represented as *trajectories* (time-ordered curves) connecting different states.
- **questo si puo' mettere all'inizio facendo un link con Gardenfors e i suoi spazi che mi sembrano molto simili**

248 Lombard: quality space

- A set S of simple (non-compound) static properties $\{P_1, \dots, P_n\}$ is a *quality space* iff:
 - (i) if at any time t an object x has $P_i \in S$ then, at t , for any $j \neq i$, it is not the case that x has $P_j \in S$.
 - (ii) if an object x has $P_i \in S$ at time t and x exists at t' but it fails to have P_i at t' , then x changes in S , that is, for some $j \neq i$, at t' , x $P_j \in S$.
- i.e.
- ▶ quality spaces consist of mutually exclusive static properties;
 - ▶ if an object changes losing a property in a quality space, it must come to have another property of the same kind.

249 Lombard: event

- Events are “exemplifyings” of *dynamic* properties, i.e. properties that items have by virtue of an alteration in what *static* properties it has (therefore events cannot be instantaneous).
- An event is a ‘movement’ by an object from the having of one to the having of another property in the same quality space where those properties are such that the object’s successive having of them implies that the object changes non-relationally.
- If an *object* changes from having P_i to having P_j at some time t , then an event is (spatially) located wherever the object is located at the time that it changes. [this causes some problem of minimality, see p.121-123]

250 How many events?

- The spinning of the ball
The warming up of the ball
- John's answering my question
John's shouting
- Brutus's stabbing Caesar
Brutus's killing Caesar
Caesar's death
- My alerting the burglar
My illuminating the room
My turning on the light
My pushing on the button
My moving my finger...

251 Event identity

- “No entity without identity”
- Identity criteria
 - ▶ Co-localization, but strong four-dimensionism
 - ▶ Causal equivalence, but temporal shifts
 - ▶ Logical equivalence, but slingshot argument
 - ▶ Many different proper ties: exemplification of proper ties at a time
- A general semantic problem? (cf. definite descriptions)
- Multiplicationism, again...

252 Identity criteria for events

- **Quine:** same spatio-temporal location (excludes the rotating and heating sphere example).
- **Davidson:** same place in the causal network, same causes/same effects (circularity in the axiom, all ineffectual events are identical, pulling the trigger vs. killing (events p.xxiii))
- **Kim:** same constituents.

253 Events, space and time

- are events in space in the same way that objects are?
- are events in time in the way objects are in space?
- are objects in time in the same way that events are?
- **Hacker:** events occur (time is directly related to events but not to objects) while objects exist (space is directly related to objects but not to events)
- **Davidson:** “Occupying the same portion of space-time, event and object differ. One is an object which remains the same object through changes, the other a change in an object or objects. Spatiotemporal areas do not distinguish them, but our predicates, our basic grammar, our ways of sorting do. Given my interest in the metaphysics implicit in our language, this is a distinction I do not

want to give up.” (Reply to Quine on Events, p.176)

254 Different kinds of Events

- activities
- accomplishments
- achievements
- states

vedi events p.xxxi

255 “Meta”-events and participation

- e.g. its coming about today that John’s birth was exactly sixty year ago” (p.371 simons)
- i.e. events can exemplify properties, therefore if, in general, events are properties exemplifications, we can have events that have events as “participants” (**vedi p.375 simons per come kim ha usato questo per i modificatori avverbiali**)
- what is the participant in “the change of intensity in a field”? Is it necessary to reify fields?
- in processes ontologies, objects are abstracted from events, therefore events do not have participants (**anche in questo caso sottolineare l’aspetto rappresentazionale, se astraggo gli oggetti da eventi, comunque sono legati a tali eventi, che potrei appunti**

indicare come i loro partecipanti)

256 Five positions (simons p.380)

- pure perdurantism: only occurrents
- pure endurantism: only continuants
- duality of equals: both continuants and occurrents exist and neither reduces to or is prior to the other
- priority endurantism: both exist but continuants have ontological priority
- priority perdurantism: both exist but occurrents have ontological priority
- **spiega quindi perche' DOLCE assume duality of equals.... e come si potrebbe indebolire per dire che una delle due categorie e' riducibile all'altra, cosa che dovremmo fare comunque**

257 Events, process modeling, and plans

- **dire magari due parole con i linguaggi di modellazione di processi come ad es. BPMN, che questi in effetti non definiscono eventi ma al massimo tipologie di eventi, che in realta' introducono un insieme di vincoli strutturali su eventi**
- **link con i piani, anche questi sono simili a descrizioni di processi, forse ancora piu' dettagliati in alcuni casi in quanto sono sequenze di azioni, ma a differenza degli eventi, lo stesso piano puo' essere ri-eseguito, mentre lo stesso evento non puo' ri-succedere**

258 Events vs. objects

da lezione 4 essli 05, preso da [Casati and Varzi, 1996]

- Endurant / perdurant discussion
- Strong four-dimentionalism: stages of objects
- Objects and events colocate differently:
 - the ball / the piece of metal
 - the spinning of the ball / the warming up of the ball
 - the music going on / the smoke lling up the room
- Objects can move, events cannot
- What relationship? existential dependence, participation

259 Events vs. facts/states of affairs

da lezione 4 essli 05, preso da [Casati and Varzi, 1996]

- Caesars death / that Caesar died, my standing here / that I am standing here
- Events are concrete (= situated in space-time), facts and soa are abstract
- Events occur once, propositions and soas can repeatedly be the case / obtain
- Caesars death = Caesars violent death, that Caesar died \neq that Caesar died violently

260 Predicates

- $\text{Red}(x) \wedge \text{Orange}(y) \rightarrow x \sim_{\mathbf{C}} y$
- $\text{Red}(x, t) \wedge \text{Orange}(y, t) \rightarrow x \sim_{\mathbf{C}, t} y$

261 Attributes

- $\text{Color}(\text{red}, x, t) \wedge \text{Color}(\text{orange}, y, t) \wedge \text{red} \sim \text{orange}$
- ▶ $\text{Red}(x, t) \triangleq \text{Color}(\text{red}, x, t)$
- ▶ $x \sim_{\text{C}, t} y \triangleq \exists c_1 c_2 (\text{Color}(c_1, x, t) \wedge \text{Color}(c_2, y, t) \wedge c_1 \sim c_2)$

262 Change

- most philosophers analyze change as involving (in the simplest case) four components: the substratum or object changing, the property or state the object has before the change, the property or state it has afterwards, and the time of change (da simons, events, hand).
- In order to something to change there must be a sense in which it remains the same (otherwise it simply ceases to exist) and a sense in which it becomes different (changes). (cleland, p.381) **(vedi def. di concrete change, p.382)**

263 Ontological levels: aims

- To develop a *formal* framework that allows to manage constitution, inherence, and abstraction (aggregation) in a *uniform* way.
- To set up this framework on the basis of general and *well-foundend primitives*.
- To highlight possible *alternative* frameworks, the comparison of which would improve our understanding of levels.
 - ▶ I do not formally explore these alternatives, I just point out some of them.

264 Entity stacking

- I will refine a multiplicative approach called *entity stacking* that is based on the notion of *existential dependence*:
 - ▶ Goliath depends on Lump1,
 - ▶ Luc-qua-passenger depends on Luc,
 - ▶ my heart depends on the on cells,but the opposite holds for none of the previous examples.
- This dependence can be generalized to kinds.
 - ▶ E.g. statues, to exist, require amounts of matter but amounts of matter can exist without any statue.

265 Grounding

- Existential dependence is often defined as $\Box(Ex \rightarrow Ey)$.
- Existential dependence of x on y “amounts to the necessary truth of a material conditional whose antecedent is about x only and whose consequent is about y only; and given that any such material conditional fails to express any ‘real’ relation between the two objects, it is hard to see how prefixing it with a necessary operator could change anything in this connection” (Correia 2002, p58).
- Grounding: an object x is grounded on a (different) object y at t if the existence of y at t makes possible the existence of x at t , i.e., x owes its existence at t to y 's existence at t .
- Grounding introduces a *factual relation* among objects.

266 The notion of level

- Grounding can stack more than one object:
 - ▶ a pebble can be grounded on an amount of matter and it can ground a paperweight;
 - ▶ cells ground organs that ground bodies that ground persons that ground organizations, etc.
- Grounding is a 'vertical' relation between objects. To group objects in levels an 'horizontal' relation is necessary.
- General relation compatible with different views on levels:
 - ▶ levels depend only on laws of nature;
 - ▶ levels are the result of a conceptualization;
 - ▶ levels correspond to (natural) kinds of objects.

267 Being at the same level as

- I consider 'being at the same level as' as an additional primitive.
- Why not assuming a recursive definition in terms of grounding?
 - ▶ Not first-order axiomatizable.
 - ▶ Requires bottom-level objects to stop the recursion.
 - ▶ Given a bottom level, hierarchies of levels build on it are linear.
- Level hierarchies are assumed as non-linear by some authors.
 - ▶ Some comparisons do not make sense: are robots on a higher level than sea slugs? (Baker 2007))
 - ▶ Levels account for conceptual points of view on reality, the same object can be seen in different ways.

268 Parthood

- A *whole*, e.g. a table, can have persistence criteria and causal powers different from the ones of its *parts*, e.g. a top and four legs. To exist, the table requires the existence of the top and the legs. Is therefore parthood just a kind of constitution or aggregation?
- The relation between parthood and constitution/aggregation is a highly debated issue complicated by the fact that there is no consensus about the core properties of parthood.
- I differentiate *grounding* from *parthood* by assuming a purely *formal* parthood: mereology just aims at referring to ‘pluralities’ (‘multitudes’) of entities without committing to sets: *mereological sums* are ‘nothing more’ than their summands.

269 Time

- To express change through time I need to consider temporal indexes.
- I want to be neutral with respect to the structure of time, therefore I consider here a very weak theory of time: basically I will consider time just as a non-structured set of indexes called *times*.

270 Formal primitives

- A logic with two sorts, *time* and *object*, distinguished by a notational convention: variables on times are noted by t , t' , t_i , etc.
- $\text{EX}_t x$ “ x exists at time t ”
- $x \prec_t y$ “ x grounds y at t ”, “ y owes its existence at t to x ”
- $x \text{tP}_t y$ “ x is part of y at t ”
- $x \equiv y$ “ x is at the same level as y ”

271 Focus

- I will discuss only some axioms that I consider important.
- The details of the axiomatization can be founded in the paper.

272 Static notion of level

- ▶ $x \equiv y$ “ x is at the same level as y ”
- Objects cannot change level through time, e.g. no object can survive a change in natural kind because no object can lose essential properties.
- *Dynamic* theories are interesting, require two temporal arguments, and are more complex from the formal point of view.

273 Down-linearity of grounding

$$\mathbf{a20} \quad y \prec_t x \wedge z \prec_t x \rightarrow y \prec_t z \vee y = z \vee z \prec_t y$$

- To account for the following intuitions:
 - ▶ Goliath is intimately connected to Lumpl, it cannot be grounded on something else at the same level;
 - ▶ two objects with different grounding are different, i.e. the difference in grounding is enough to distinguish them.
- (a20) is too strong if grounding is a simple existential dependence:
 - ▶ one objects can depend on all its parts (all at the same level);
 - ▶ relational tropes can, in principle, depend on objects belonging to different levels (that do not depend one on the other).

274 Generic dependence between levels

a22 $x \equiv y \wedge u \prec_t x \wedge \mathbf{EX}_{t'} y \rightarrow \exists v (v \equiv u \wedge v \prec_{t'} y)$

- Entities belonging to higher levels depend on lower level entities.
- (a22) partially characterizes the notion of level.

275 One-level objects

$$\mathbf{d14} \quad 1\mathbf{L}x \triangleq \forall yt(y\mathbf{tP}_t x \rightarrow y \equiv x)$$

$$\mathbf{a30} \quad x \equiv y \rightarrow 1\mathbf{L}x \wedge 1\mathbf{L}y$$

$$\mathbf{a31} \quad x \prec_t y \rightarrow 1\mathbf{L}x \wedge 1\mathbf{L}y$$

- (a30) and (a31) assure that \equiv and \prec apply to objects with parts belonging to different levels.
- Is it not clear to me what \equiv and \prec mean for multi-level objects, some options exist.
- (a30) and (a31) do not exclude the existence of multi-level objects (in particular parthood is not defined only on one-level objects).

276 Partial grounding

d15 $x \prec_t y \triangleq \exists z(x \mathbf{tP}_t z \wedge z \prec_t y)$ (partial grounding)

t15 $z \prec_t y \wedge y \prec_t x \rightarrow z \prec_t x$

t20 $\neg x \prec_t x$

t24 $\exists a(x \mathbf{tPP}_t a \wedge a \prec_t y) \rightarrow \exists z(z \equiv x \wedge z \prec_t y \wedge \neg z \mathbf{tO}_t x)$

- (t24) is similar to weak supplementation of parthood.
- Partial grounding satisfies properties very similar to the ones assumed for *minimal mereology* (Casati&Varzi 1999).
- In my understanding, this explains why some authors use parthood to represent constitution or partial grounding. However some links between \prec and \mathbf{tP} or \equiv are not considered in any mereology.

277 Constitution

- At a given level and time, the grounding of an object is unique, therefore *constitution* can be directly represented by grounding.
- Constitution implies spatial co-location. Here I have not addressed this aspect but I think it is not difficult to extend the theory to take into account space.
- Who prefers a notion of partial constitution can use partial grounding.
- Note however that in my theory partial grounding and parthood are two different relations:

$$\mathbf{t14} \quad x \triangleleft_t y \rightarrow \neg y \mathbf{t} P_t x$$

278 Inherence

- While constituted objects can change their constituents across time, qua entities inhere in the same object during their whole existence.
- In addition inherence is generally assumed to satisfy the *non-migration principle*: a qua-entity inheres in a unique object (t^{**}).

$$\mathbf{d19} \quad x \odot_t y \triangleq x \prec_t y \wedge \neg \exists z (x \prec_t z \wedge z \prec_t y) \quad (\text{direct grounding})$$

$$\mathbf{d20} \quad x \text{IN} y \triangleq \forall t (\mathbf{EX}_t x \rightarrow y \odot_t x) \quad (\text{inherence})$$

$$\mathbf{t^{**}} \quad x \text{IN} y \wedge x \text{IN} z \rightarrow y = z$$

279 Granularity

- The distinction between parthood and grounding allows to address *granularity* by considering *atoms* (objects without proper parts) that are grounded on non-atomic objects.
- I considered just a very trivial theory of granularity.
- The following assumptions can quite easily be characterized in terms of the presented theory:
 - ▶ objects are ultimately (mereologically) composed by atoms;
 - ▶ higher levels are coarser than lower ones (i.e. atoms are grounded on non-atoms;
 - ▶ higher atoms *partition* lower ones (i.e. any lower level atom partially grounds one and only one high level atom).