

BFO/DOLCE Primitive Relation Comparison

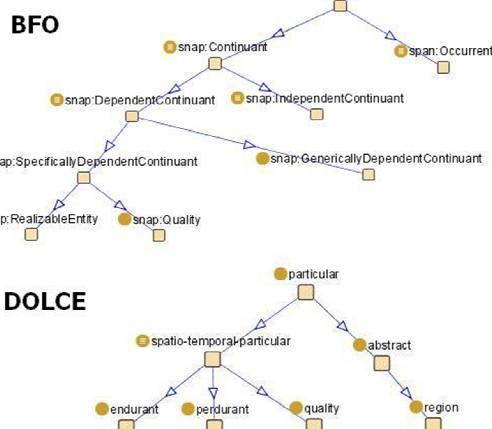
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INTRODUCTION

Successful integration of domain ontology types with those of an upper ontology allows for cross-domain reasoning and overall data integration, facilitating progress in life sciences research and health care. BFO¹, Basic Formal Ontology, and DOLCE², Descriptive Ontology for Linguistic and Cognitive Engineering, are two widely used upper ontologies, especially for the development of ontologies in the biomedical sciences. While BFO is based in realism, DOLCE takes perceptual experience into account. For BFO, these axioms are formalized within the Relation Ontology (RO)³, which is a part of the collaborative science-based Open Biomedical Ontologies (OBO)⁴ Foundry effort. BFO holds true to realism by attempting to capture what actually exists and occurs in the world, independent of epistemological concerns.

This paper provides a comparison of the primitive relations and respective axioms defined for BFO and DOLCE, preceded by a brief discussion of their original treatment in the philosophical literature. Note that BFO uses the terms *continuant* and *occurrent*—while DOLCE uses *endurant* and *perdurant*—to denote entities that persist and those that happen in time, respectively.



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CONSTITUTION

Constitution is a more general sense of composition—which denotes ‘is made of’—which helps describe particulars like living organisms that are naturally in flux⁵. A body constitutes a person, and there are bodily functions (e.g., heartbeat) that if they were to cease, the body would continue to exist but the person would not. Thomson⁶ uses the relationship between a lump of clay and the statue it constitutes to argue that constitution is not equivalent to identity, since they can have different histories, different persistent conditions and differences in essential relational properties.

BFO on Constitution

Since BFO is based on realism and aligned with the Dichronic View⁶, which holds that two things cannot exist at the same time and space, constitution is not a suitable primitive relation. In the vase and the clay scenario, BFO’s position is that a vase is just clay in a certain shape⁷. Nevertheless, a relation that shares similarities with constitution is BFO’s ‘role of’. It is intuitive that a hand plays the ‘role of’ a fist when clenched, as it is that a person plays the role of nurse when employed as one in a hospital. Fitting the definition of constitution, the properties of being clenched or employed are not essential to a hand or a person to continue persisting in time.

DOLCE on Constitution

In DOLCE, constitution holds between endurants or perdurants at a given time. As with dependence, relations of constitution include constant specific and constant generic forms. Additionally, one-sided constant specific, one-sided constant generic, mutual specific and mutual generic characterizations of the relation are defined.

DEPENDENCE

Logical dependence concerns the relationship between propositions; ontological dependence is between objects in general. Generic dependence is dependence on something that can change from one time to another; specific dependence is dependence on a particular that must always be the same. **Every gene is generically dependent on its nucleotides, every cell’s shape is a quality of its cell.**

BFO on Dependence and Quality

In BFO via RO dependence is labeled with ‘inheres in’ and holds between independent and dependent continuants. Specializations of ‘inheres in’ include: ‘function of’ for functions (internally grounded) and ‘role of’ for roles (externally grounded). The respective entities are actualized by certain kinds of processes⁸, whereas qualities are only dependent on the existence of the independent continuant they inhere in.

For instance, *taq polymerase* has the ‘function of’ *withstanding protein denaturing conditions* (i.e., high temperature)⁹, and the *GFP gene* can play the ‘role of’ *reporter gene* when fused to a promoter gene¹⁰.

DOLCE on Dependence and Quality

DOLCE defines ‘quality of’ as a relation between a quality, and another quality, endurant, or perdurant. In BFO the ‘quality of’ relation cannot hold between qualities, or between qualities and occurrents. BFO however admits to the utility “pseudo” relation (e.g., ‘realized by’) to associate qualities directly with processes. In this same vein, Ceusters¹¹ provides a distinction between terminologies that are dependent on first-order reality (e.g., specific patients, lab results), second-order reality (e.g., interpretations, clinician opinions), and information about the former two (e.g., entries in a database), in support of ontological analysis. Rosse¹² describes three levels of representation: 1) **upper ontology**, 2) **domain reference ontologies**, and 3) **terminology-based application ontologies**. Domain reference ontologies are considered extensions of upper ontologies, and “declare a theory about a particular domain of reality”, while terminology-based application ontologies are designed strictly for particular purposes, and considered “controlled vocabularies”. With these levels in mind, the issue is more clearly seen as at which level certain relationships should be represented, instead of whether they should be represented at all. Still, as to what are the ramifications of the level of representation chosen remain an open question.

DOLCE also includes a relation ‘quale of’ holding between qualities and qualia. A quality of a rose is its color, which is a physical quality inhering in a physical endurant. However, the ‘quale of’ its color is its specific shade, which according to DOLCE is described by the position (i.e., region) of a quality in a quality space² (e.g., color space), as inspired by Gärdenfors¹³. Also in DOLCE, a physical or abstract region is a ‘quale of’ a physical or abstract quality, respectively, at a given time. In DOLCE, regions are abstract particulars, as are propositions and sets. A quale only exists as a reflection of ‘perceptual and cognitive bias’¹², which is a direct contrast with BFO’s realism-based approach, which only considers entities located in space and time.

DOLCE also includes entities that do not naturally occur in the world but in thought. As a result of its realistic underpinnings, **BFO observes that qualities only inhere in continuants, and those that are only available through the human perceptual lens are not bona fide, falling to subjectivism.**

Conceptual spaces are a convenient way to explain how living beings model the world internally through perceptual experience. Color space is one of the few quality dimensions constituting conceptual spaces that have a well-developed theory, but that is not to say the theory has a clear correspondence with what it is representing in the world. “Scientists persist in referring to the physical characteristics of the stimulus and to the tuning characteristics of the cones as if psychological color terms like red, green, and blue had some straightforward translation into physical reality, when in fact they do not”¹⁴.

CONCLUSIONS

Future work on this topic should inspect biomedical domains that take into account what might be dubbed conceptual spaces. It should be evaluated whether or not there is a direct link to the natural world, and regardless, to what extent BFO can assist in modeling these types of domains in a manner that does not contradict its philosophical underpinnings. This and the current investigation can be fruitful in creating a unified upper ontology, and can benefit the biomedical sciences in investigating ways of accurately describing complex phenomena of each field.

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