A modelling pattern for multi-track dispositions for life-science ontologies

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ABSTRACT

Motivation: This paper extends Röhl & Jansen's (2011) model of dispositions by introducing a relation of parthood between dispositions to formalize multi-track dispositions.

Results: We suggest axioms for parthood relations between dispositions and discuss possible applications to life sciences.

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1 INTRODUCTION

Dispositions are realizable entities - properties of material objects that are realized by certain types of processes (Jansen, 2007; Arp, Smith and Spear 2015). In particular, dispositions are realizable entities that provide their bearers with certain causal powers. The *Basic Formal Ontology* (BFO) defines a disposition as a realizable entity "that exists because of certain features of the physical makeup of the independent continuant that is its bearer" (Arp, Smith and Spear, 2015, 178).

The biomedical world is full of such powers: many organisms have a disposition to proliferate; enzymes have the disposition to facilitate, accelerate or inhibit reactions; drugs have both therapeutic dispositions and dispositions for adverse effects. For this reason, Röhl and Jansen (2011) suggested a modelling pattern for dispositions for use in biomedical ontologies. This pattern, however, was restricted to single-track dispositions, i.e. to dispositions that show exactly one kind of realization given one specific bundle of triggering events and/or background conditions. This falls short of the complexity of the biomedical world.

In this paper we suggest a pattern to represent more complex dispositions, taking into account both the possibility of several kinds of triggers as well as of several kinds of realizations. The challenge is that triggering conditions and realizations come in well-defined pairs. For example, a magnet has the disposition to attract another magnet when facing an unlike pole, and it has the disposition to repulse the very same magnet when facing a like pole. Both dispositions are explained by the very same physical structure and laws. We suggest to model this situation by treating these two single-track dispositions as composing a complex disposition, related by a special parthood relation.

2 DISPOSITION-PARTHOOD

In the following, terms for instances and relations will be written in bold, and classes will be italicized. Consider the fragility of a glass **g**, which can be manifested by cracking (R_1) in case of light shock (T_1) and breaking (R_2) in case of more serious shock (T_2). This can be formalized by the glass having a disposition $\mathbf{d_1}$ instance of a universal D_1 to R_1 in case of T_1, and a disposition $\mathbf{d_2}$ instance of a universal D_2 to R_2 in case of T_2. Following Röhl and Jansen's model (2011), we would have:

- D_1 subClassOf $\mathbf{has\_trigger_D}$ only T_1
- D_1 subClassOf **has_realization** only R_1
- D_2 subClassOf $\mathbf{has\_trigger_D}$ only T_2
- D_2 subClassOf **has_realization** only R_2

Note first that such axioms do not violate the actualist philosophical stance of BFO. Even if an instance $\mathbf{d_1}$ of D_1 is never triggered (and thus, there is no $\mathbf{t_1}$ **instance_of** T_1 such that $\mathbf{d_1}$ **has_trigger** $\mathbf{t_1}$), the class T_1 has some instances at some time (even if they do not trigger $\mathbf{d_1}$) and therefore it exists. However, "fragility" is arguably one single entity – which may be seen as a disposition $\mathbf{d_0}$ instance of a universal D_0 to R_1 in case of T_1 and to R_2 in case of T_2. In a first attempt, we may want to introduce D_0 such that D_1 subClassOf D_0 and D_2 subClassOf D_0, characterizing D_0 with the following axioms:

- D_0 subClassOf $\mathbf{has\_trigger_D}$ only (T_1 or T_2)
- D_0 subClassOf **has_realization** only (R_1 or R_2)

This way, however, we would lose a lot of information, like the information that an instance of R_1 is always triggered by an instance of T_1.

Therefore, we introduce instead a relation **d-part_of** between dispositions, such that, at the instance level, $\mathbf{d_1}$ **d-part_of** $\mathbf{d_0}$, and $\mathbf{d_2}$ **d-part_of** $\mathbf{d_0}$. At the universal level, we would have D_1 subClassOf **d-part_of** some D_0, and D_2 subClassOf **d-part_of** some D_0. This allows to formalize dispositions that are multi-triggers and multi-realizations: D_0 can be said to have several types of triggers (T_1 and T_2) and several types of realizations (R_1 and R_2) – or, more generally, several tracks (T_1 leading to R_1 and T_2 leading to R_2).

One question is whether **d-part_of** is an authentic parthood relation. There does not seem to be an apriori objection for a parthood relation to hold between dispositions, as parthood does not hold necessarily between material entities only, as underlined by Varzi (2016). The definition of **part_of** (BFO_0000050) in the Relation Ontology (RO) (Arp, Smith and Spear, 2015) associated with BFO is generic enough also to comprise relations between dependent continuants; hence we can introduce **d-part_of** as a sub-relation of **part_of**.

This relation is reflexive, antisymmetric and transitive, and thus a partial order, like classical relations of parthood. As an example for transitivity, consider the disposition of aspirin to relieve headaches, which is **d-part_of** the disposition to relieve pain, which in turn is **d-part_of** aspirin's overall disposition to physiological effects, of which the first one is also a d-part. Defining **has_d-part** as the inverse relation of **d-part_of**, we can then model the magnet example by stating that *Magnet* subClassOf **has_disposition** some *Ferromagnetic_Disposition*, and *Ferromagnetic_Disposition* sub-

ClassOf **has_d-part** some D_1 (resp. some D_2). Now the pattern from Röhl and Jansen (2011) can be used to model the two partial dispositions D_1 and D_2:

- D_1 subClassOf **has_bearer** some *Magnet*
- D_1 subClassOf $\mathbf{has\_trigger_D}$ only '*Unlike pole approximation process'*
- D_1 subClassOf **has_realization** only '*Attraction process'*

D_2 can be formalized along similar lines, with the '*Like pole approximation process'* as trigger and *'Repulsion process'* as realization. We consider introducing the additional following axioms (with $\mathbf{d_0}$ and $\mathbf{d_1}$ being particular dispositions):

- If $\mathbf{d_1}$ **d-part_of** $\mathbf{d_0}$, then: **x bearer_of** $\mathbf{d_1}$ iff **x bearer_of** $\mathbf{d_0}$.
- If $\mathbf{d_1}$ **d-part_of** $\mathbf{d_0}$ and $\mathbf{d_1}$ **has_realization r**, then $\mathbf{d_0}$ **has_realization r**.
- If $\mathbf{d_1}$ **d-part_of** $\mathbf{d_0}$ and $\mathbf{d_1}$ **has_trigger t**, then $\mathbf{d_0}$ **has_trigger t**.

Note that not all relations between dispositions can be dealt with in this model. E.g., the disposition of the candle wax to melt surely contributes to the disposition a candle to burn when lighted, but it is not captured by **d-part_of**, because both dispositions have different bearers.

3 DISCUSSION

If **d-part_of** is to be a parthood relation, it should also satisfy principles of decomposition and composition (Varzi, 2016). If **PP** is the relation of "proper_part_of", **P** the relation "part_of" and **O** the relation "overlaps", the following variants of decomposition principles are distinguished (Varzi, 2016):

- (Weak supplementation) $\mathbf{PP}xy \rightarrow \exists z\,(\mathbf{P}zy \wedge \neg \mathbf{O}zx)$
- (Strong supplementation) $\neg\mathbf{P}yx \rightarrow \exists z\,(\mathbf{P}zy \wedge \neg \mathbf{O}zx)$
- (Complementation) $\neg\mathbf{P}yx \rightarrow \exists z\,\forall w\,(\mathbf{P}wz \leftrightarrow (\mathbf{P}wy \wedge \neg\, \mathbf{O}wx))$
- (Atomistic supplementation) $\neg\mathbf{P}xy \rightarrow \exists z\,(\mathbf{A}z \wedge \mathbf{P}zx \wedge \neg\mathbf{P}zy)$

where "$\mathbf{A}z$" means that z is an atom, i.e., an entity that cannot be decomposed further.

Arguably there are no atomistic dispositions, for both realization and trigger types can always be more fine-grained. However, **d-part_of** seems to satisfy the principle of complementation, and therefore of weak and strong supplementation.

A more debatable question is whether arbitrary sums of dispositions also do exist. That is, for any dispositions $\mathbf{d_1}$ and $\mathbf{d_2}$, is there always a disposition that is the mereological sum of $\mathbf{d_1}$ and $\mathbf{d_2}$? It might be strange to say that a patient not only has the disposition to vomit and the disposition to develop an allergic reaction, but also the complex disposition to vomit or to react allergically. However, this kind of entity might be useful for some computer applications, and it is not absurd to say that they exist as particulars - the same way that there might exist so-called "junk particulars", such as "the mereological sum of Bush's right knee and the pain in Clinton's left leg" (Smith, 2004). However, such dispositions run counter to the intuition that a bona fide complex disposition should show some kind of unity. Along this line, one can point out that the two dispositions of the patient (to vomit and to react allergically) can vary independently from each other; the patient can lose or gain any of them without losing or gaining the other. The situation is different in the case of the magnet: It is the very same physical structure that leads both to the magnet's attraction power and its repulsion power. In order to change the one, we need to change the other. Hence it might be a viable strategy to account for the unity of complex disposition in terms of the physical structure that constitutes it, the so-called 'categorical base' of a disposition (Röhl & Jansen, 2011).

As dispositions are continuants, the dispositions of a particular object can therefore change over time. In order to account for this, we suggest the adaption of the temporally qualified continuant approach (Grewe & Jansen, 2013) to formalize such changes. Finally, various probabilities might be assigned to the various tracks of a multi-track disposition, adapting the methodology developped by Barton, Burgun & Duvauferrier (2012).

4 APPLICATIONS TO LIFE SCIENCES

This model could be useful in life sciences, in particular to formalize diseases and drugs. First, a disease is formalized as a disposition in OGMS (Scheuermann et al., 2011). However, a disease can have different kinds of disease courses – which are the realizations of the disease. Second, a drug has several dispositions to have various physiological effects, in various situations. In sum, the proposed pattern should enhance expressivity for the modelling of dispositions in biomedical ontologies.

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REFERENCES

Arp, R., Smith, B., & Spear, A. D. (2015). *Building ontologies with basic formal ontology*. MIT Press, Cambridge MA.

Barton, A., Burgun, A., & Duvauferrier, R. (2012) Probability assignments to dispositions in ontologies. In *Proceedings of the 7th International Conference on Formal Ontology in Information Systems (FOIS)*, pp. 3-14, IOS Press, Amsterdam.

Jansen, L. (2007). Tendencies and Other Realizables in Medical Information Sciences. *The Monist*, *90*(4), 534–554.

Jansen L. and Grewe N., (2014) Butterflies and Embryos: The Ontology of Temporally Qualified Continuants. In *Ontologies and Data in Life Sciences (ODLS 2014),* p. E1-5, Universität Leipzig, Leipzig.

Röhl, J., and Jansen, L. (2011). Representing dispositions, *Journal of Biomedical Semantics*, **2**(Suppl 4), S4.

Scheuermann, R. H., Ceusters, W., & Smith, B. (2009). Toward an ontological treatment of disease and diagnosis. In *Proceedings of the 2009 AMIA Summit on Translational Bioinformatics*, p. 116–120, San Francisco CA.

Smith, B. (2004) Beyond concepts: ontology as reality representation. In *Proceedings of the 3rd international conference on formal ontology in information systems (FOIS)*, pp. 73-84, IOS Press, Amsterdam.

Varzi, A. (2016). Mereology. In Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy* (*Winter* 2016 *Edition*).