

On domain adjectives and the metaphors they modify

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Abstract

The metaphorical meaning of a noun like *storm* is modeled as a function from domains to kinds of storms. The argument of this function can be set by a domain adjective (e.g., a *political storm*), but also adverbially or contextually. By making explicit how domain specification works, this proposal not only brings conceptual domains and metaphors into the heart of formal semantics, but it also opens avenues towards an account of non-metaphorical domain modifiers more generally (e.g., *botanical fruit*).

1 Introduction

The adjectives in (1) are examples of *domain adjectives*: they can specify the domain in which the noun they modify is interpreted (Ernst, 2004). An *academic crusade*, for instance, is a crusade in the domain of academia.

- (1) academic, budgetary, conceptual, culinary, economic, emotional, financial, political, psychological, spiritual

It has been observed that these adjectives can shift the meaning of their noun to a metaphorical meaning (Sullivan, 2013; Reijnierse, Burgers, Krennmayr, & Steen, 2018).

- (2) spiritual wealth, emotional scar, financial octopus, psychological jungle, political storm, academic crusade, economic midget, conceptual space, budgetary anorexia, culinary mecca

In the examples in (2), the noun gives the *source* of the metaphor (e.g., the many-tentacled octopus in *financial octopus*) that is mapped to a *target* from the adjectival domain (e.g., a large and diversified financial institution). This is a fully productive process (Hanks, 2004). We can have octopuses in as many domains as we have domain adjectives (3a) and the domain adjective *spiritual* can specify the target domain of an open-ended range of metaphorically used nouns (3b):

- (3) a. bureaucratic / cultural / electronic / financial / political / ... octopus
b. spiritual food / growth / path / pollution / vacuum / warfare / ...

As section 2 will show, domain adjectives share properties with the more intensively studied *relational* adjectives, like in *solar heat*, *technical architect*, *musical instrument* (McNally & Boleda, 2004), but there are also important differences. A domain adjective can not simply be treated as an instance of a relational adjective, but a dedicated account is needed to explain how the meaning of the noun can shift from one domain to another depending on the adjective that modifies it, but also under the influence of the context or of a sentential adverb. This account has to address questions about how word meanings interface with

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compositional meaning (section 3). The proposal of this paper (worked out in section 4) is that the metaphorical meaning of a noun like *storm* is modeled as a function from domains to kinds of storms. The argument of this function can be set locally, by a domain adjective (e.g., a *political storm*), but also adverbially or contextually. Section 5 concludes the paper with an brief exploration of the wider perspectives. By making explicit how domain specification works, this proposal not only brings conceptual domains and metaphors into the compositional heart of formal semantics, but it also opens avenues towards an account of non-metaphorical domain modifiers more generally (e.g., *botanical fruit*).

2 Domain adjectives

In many respects, domain adjectives are similar to relational adjectives (McNally & Boleda, 2004). Like relational adjectives, domain adjectives do not allow for a predicative use (4). Without the noun, the adjectives sound odd for the same subject or they have a different meaning.

- (4) a. Chris is a technical architect. (relational adjective)
 a'. ?Chris is technical.
 b. Citicorp is a financial octopus. (domain adjective)
 b'. ?Citicorp is financial.

Domain adjectives are also similar to relational adjectives in not allowing (degree) modification (5). Even though the adjectives *technical* or *bureaucratic* allow for such modification in other functions (5a''/b''), this modification is incompatible with their function as a relational or domain adjective (5a'/b').

- (5) a. Chris is a technical architect. (relational adjective)
 a'. ?Chris is a very technical architect.
 a''. This is a very technical job./The job is very technical.
 b. The EU is a bureaucratic octopus. (domain adjective)
 b'. ?The EU is a very bureaucratic octopus.
 b''. This is a very bureaucratic process./The process is very bureaucratic.

Like a relational adjective, a domain adjective also needs to come closer to the noun than other adjectives (6).

- (6) a. a young technical architect/?a technical young architect (relational adjective)
 b. a huge financial octopus/?a financial huge octopus (domain adjective)

Finally, like relational adjectives, domain adjectives are morphologically complex (7), with a derivational suffix that suggests a relation with a noun. This relation is usually not a simple matter of affixation (as usual in derivational morphology): *solar* relates to *sun*, *financial* to *finances*, *academic* to *academia*, and *culinary* to *kitchen*. Nevertheless, domain adjectives typically seem to be in a paradigmatic relation (in the morphological sense) with a noun that refers to the same domain. This is why an *academic crusade* can also be described as a *crusade in academia* or the *culinary mecca* the *mecca of the kitchen*.

- (7) a. *solar* heat, *technical* architect, *musical* instrument (relational adjective)
 b. *financial* octopus, *academic* crusade, *culinary* mecca (domain adjective)

However, domain adjectives also differ from relational adjectives in a number of ways. First, domain adjectives do not establish a relation between the noun referent and another entity. As the label indicates, such a relation has often been pointed out for relational adjectives.

We can describe *solar heat* as ‘heat coming from the sun’ and a *financial advisor* as a ‘person who advises about finances’. This is different with domain adjectives. A financial octopus is not an octopus related to finances in the way that a financial advisor is an advisor related to (namely, advising about) finances. There is something about heat and advisors that provides the starting point for a relation with the sun and finances, respectively, but that is not the case with an octopus. The only prepositions that might be possible here are *of* and *in* (*the octopus of/in finances*), but these prepositions then play the more general role of relating the notion of octopus to a domain.

Domain adjectives are also not straightforwardly subsective, unlike relational adjectives. (8a) entails (8b) in every context, making *technical* a subsective adjective. It is harder to accept (9b) as an automatic entailment of (9a) in every context. The reason is that *octopus* has a metaphorical meaning in (9a) that it only has in (9b) in certain contexts.

- (8) a. Chris is a technical architect. (relational adjective)
 b. Chris is an architect.
- (9) a. Citigroup is a financial octopus. (domain adjective)
 b. Citigroup is an octopus.

Finally, domain adjectives are also different from relational adjectives in having an adverbial, sentential counterpart (10). It is not possible to paraphrase (8a) above, with the relational adjective, as (10a) below. The adverb *technically* in (10a) does not specify the *type* of architect Chris is. As pointed out in Ernst (2004), a domain adjective (9a) has a domain adverb (10b) as a counterpart. Such paraphrases are always possible for domain adjectives, but never for relational adjectives.

- (10) a. Technically, Chris is an architect. (\neq (8a)) (relational adverb)
 b. Financially, Citigroup is an octopus. ($=$ (9a)) (domain adverb)

3 The challenge of domain adjectives

We have seen that the phrase *financial octopus* refers to financial institutions that are similar to octopuses in certain respects. How is that interpretation derived from the interpretations of its two constituents, the domain adjective *financial* and the noun *octopus*? One might think that the easiest solution is to keep metaphor safely ‘in the lexicon’ as a part of lexical semantics. The combinatorial system takes a word like *octopus* from the lexicon with either a non-metaphorical meaning (say **octopus**) or a pre-packaged metaphorical meaning (say **m-octopus**) and it combines it with the meaning of the adjective, leading to either **financial(octopus)** or **financial(m-octopus)**. Only the second combination makes sense (because there is nothing financial about real octopuses) and this second combination therefore can have referents in the financial domain.

The problem with keeping metaphor entirely *inside* the lexicon is that the metaphorical meaning of the noun *octopus* depends on something *outside* the lexicon. This can either be an explicit local modifier (11a), a non-local modifier (11b), or the general context (11c). A financial octopus is something different than a bureaucratic or an electronic octopus and therefore it is hard to see how the choice of a *particular* metaphorical meaning for *octopus* can be made lexically, before it enters the compositional process.

- (11) a. It is a financial octopus.
 b. Bureaucratically, it is an octopus.
 c. How can we handle this octopus? (talking about a computer network)

One response might be that this problem does not arise when **m-octopus** corresponds to the widest possible sense of the word *octopus*, including anything that is similar to a octopus (like diversified financial institutions, complex government organizations, sprawling computer networks). What we see in (11) are simply ways to pick out specific subsets from this wide superset. The domain adjective in (11a) simply works intersectively, selecting those entities similar to octopuses that are at the same time financial entities.

$$(12) \quad \lambda x [\mathbf{m-octopus}(x) \wedge \mathbf{financial}(x)]$$

The problem with (12) is that it is incompatible with the non-predicative behaviour of domain adjectives that we mentioned in (4b'). Another problem with (12) is that this kind of local and explicit intersection does not work when the domain delimiter is not local (11b) or explicit (11c).

The kind-based analysis of relational adjectives (McNally & Boleda, 2004) goes only some way to address this problem. Extending their proposal, we could treat both the metaphorical noun as well as the domain adjective as predicates over *kinds* (variable k), instead of ordinary individual entities (variable x). The two kind denotations can be intersectively combined (13a), and related by a realization relation (**R**) to ordinary individuals (13b).

$$(13) \text{ a. } \text{financial octopus} \quad \lambda k [\mathbf{m-octopus}(k) \wedge \mathbf{financial}(k)]$$

$$\text{ b. } \text{be a financial octopus} \quad \lambda x \exists k [\mathbf{R}(x,k) \wedge \mathbf{m-octopus}(k) \wedge \mathbf{financial}(k)]$$

m-octopus denotes the set of kinds of things that are 'like' the octopus, in the metaphorical sense, including financial conglomerates, complex organizations, and electronic networks. The predicate **financial** picks out a proper subset of these kinds. This solves the problem of the non-predicative nature of domain adjectives: (4b') is ruled out because the subject *Citicorp* denotes an individual, while the predicate *financial* denotes a set of kinds (a sortal mismatch). However, we are still left with the question how a sentential adverb like *bureaucratically* can restrict the set of octopus kinds that are introduced through the noun in (11b) to the bureaucratic ones. More generally, the problem of the analysis in (13) is that it treats domain adjectives in the same way as relational adjectives. The notion of domain plays only an indirect and implicit role. As a result, the differences between domain adjectives and relational adjectives are left unaccounted for and the crucial question unanswered: what makes an adjective like *financial* a *domain* modifier in *financial octopus*?

4 The analysis of domain adjectives

The proposal of this paper is to make the role of metaphorical target domains explicit in the compositional semantics. If we want to understand how the meaning of a noun can be metaphorically shifted by domain adjectives, but also by other mechanisms (domain adverbs and context), then it makes sense to represent these domains somehow. They should not be confined to the lexicon, but made accessible for the compositional semantics. There are different ways to do this. This paper makes them maximally explicit as a sort of entities that variables in the logical interpretation language can refer to.

We assume a set D of *domains*, i.e. $D = \{ \mathbf{finances}, \mathbf{bureaucracy}, \mathbf{electronics}, \dots \}$. This set might have some structure, with one domain being a subdomain of another domain or the meet of two other domains, but that is not directly relevant for our purposes. They could be seen as 'pointers' to more complex and meaningful structures. From a cognitive perspective, domains could be seen as conceptual spaces in the sense of Gärdenfors (2000), that is, combinations of different quality dimensions that allow us to construct the concepts that belong to that domain. From the computational perspective of distributional semantics

they could be seen as areas of ‘topical similarity’ in a large, multidimensional space of word vectors (Clark, 2015). Or they could be seen as (constellations of) frames (Stickles, David, Dodge, & Hong, 2016).

We also assume a set K of *kinds*, with their own appropriate (taxonomic) structure but also with a particular relation to domains. This set will contain as elements such kinds as **octopus**, **storm**, and **scar**, each corresponding to their own (source) domain. The source domain that **storm** lives in would be **meteorology**, for instance. Kinds in a domain could be seen as regions in a conceptual space (Gärdenfors 2000), as word vectors (McNally 2017), or as nodes in a frame (Stickles, David, Dodge, & Hong, 2016).

What we need now is some way of implementing the idea of a conceptual metaphor as a mapping from a source domain to a target domain. Let us say that we can map a kind k to a domain d , resulting in a new kind k' that is the metaphorical counterpart of k in target domain d . For example, the result of mapping **octopus** to **finances**, represented as **octopus** \triangleright **finances** here, is the ‘counterpart’ of **octopus** in the **finances** domain. The kind **octopus** \triangleright **finances** is not an animal anymore, but a financial object that preserves properties of the octopus that are compatible with the financial domain. The operation \triangleright could be seen as a structure-preserving embedding of a concept in another conceptual space or as an algebraic transformation in a space of word vectors (Gutiérrez et al. 2016).

In principle, every kind has the potential now to be metaphorically instantiated in different domains (to the extent that its structure is preserved in those domains). It makes sense then to define, for a kind like **octopus**, a function λd **octopus** $\triangleright d$ that maps a target domain d to the metaphorical octopus **octopus** $\triangleright d$ in that domain. If that function applies to **finances**, we get λd .**octopus** $\triangleright d$ (**finances**) = **octopus** \triangleright **finances**. This function gives us an individual concept, corresponding to the noun *octopus*, with the target domains have the role that *indices* play in intensional models: they allow us to relativize semantic values. In our case, metaphorical meanings can be relativized to target domains. Instead of the unanalyzed **m-octopus** that we had earlier, we now have an operator **m** that can be defined in terms of \triangleright and that lifts the non-metaphorical kind reference of a noun to its metaphorical, domain-dependent meaning: $\mathbf{m}(\mathbf{octopus}) = \lambda k \lambda d k \triangleright d (\mathbf{octopus}) = \lambda d \mathbf{octopus} \triangleright d$.

Building on this, a domain adjective can be analyzed as saturating the domain parameter of its noun. The adjective *financial*, for instance, takes the metaphorical meaning n of its nominal argument (a function from domains to kinds) and applies it to the domain **finances**, yielding the kind that corresponds to that domain. The lambda term of *financial* can be written as $\lambda n.n(\mathbf{finances})$. This allows (4b) to be compositionally interpreted as in (14). The metaphorical lifting is specified in step (14b). A shortcut is taken in (14f): *is a* is directly linked to the lambda term $\lambda k.\lambda x.\mathbf{R}(x,k)$ that maps kinds to their instantiations.

- | | | |
|---------|-----------------------------|---|
| (14) a. | octopus | octopus |
| b. | (metaphorical noun lifting) | $\mathbf{m} = \lambda k \lambda d k \triangleright d$ |
| c. | octopus | m(octopus)
= $\lambda k \lambda d k \triangleright d (\mathbf{octopus})$
= $\lambda d \mathbf{octopus} \triangleright d$ |
| d. | financial | $\lambda n n(\mathbf{finances})$ |
| e. | financial octopus | $\lambda n n(\mathbf{finances}) (\lambda d \mathbf{octopus} \triangleright d)$
= octopus \triangleright finances |
| f. | is a | $\lambda k \lambda x \mathbf{R}(x,k)$ |
| g. | is a financial octopus | $\lambda k \lambda x \mathbf{R}(x,k) (\mathbf{octopus} \triangleright \mathbf{finances})$
= $\lambda x \mathbf{R}(x, \mathbf{octopus} \triangleright \mathbf{finances})$ |
| h. | Citicorp | c |

- i. Citicorp is a financial octopus $\lambda x \mathbf{R}(x, \mathbf{octopus} \triangleright \mathbf{finances})(\mathbf{c})$
 $= \mathbf{R}(\mathbf{c}, \mathbf{octopus} \triangleright \mathbf{finances})$

The result of this derivation treats Citicorp as a realization of the financial counterpart of the octopus kind.

If there is no domain adjective, then the domain variable remains a free variable at the nominal level. One option is to specify this variable higher up in the structure by a domain adverb. (15) below shows how this is derived. The lambda term $\lambda d. \mathbf{octopus} \triangleright d$ in (15a) that corresponds to the noun *octopus* (after metaphorical lifting) applies in (15b) to a variable d' that is abstracted over in step (15d) of the derivation, allowing the domain adverb *financially* (15e) to apply to the resulting function from domains to truth values (15f). (The variable s ranges over functions from domains to truth values, so the domain adverb *financially* is itself a function from such functions to truth values, or, equivalently, the set of all sets of domains that contain the **finances** domain.)

- | | | |
|---------|-------------------------------------|--|
| (15) a. | octopus | $\lambda d \mathbf{octopus} \triangleright d$ |
| b. | octopus | $\lambda d \mathbf{octopus} \triangleright d (d') = \mathbf{octopus} \triangleright d'$ |
| c. | Citicorp is an octopus | $\mathbf{R}(\mathbf{c}, \mathbf{octopus} \triangleright d')$ |
| d. | (abstraction) | $\lambda d' \mathbf{R}(\mathbf{c}, \mathbf{octopus} \triangleright d')$ |
| e. | financially | $\lambda s s(\mathbf{finances})$ |
| f. | Financially, Citicorp is an octopus | $\lambda s s(\mathbf{finances})(\lambda d' \mathbf{R}(\mathbf{c}, \mathbf{octopus} \triangleright d'))$
$= \mathbf{R}(\mathbf{c}, \mathbf{octopus} \triangleright \mathbf{finances})$ |
| g. | Citicorp is an octopus | $\mathbf{R}(\mathbf{c}, \mathbf{octopus} \triangleright d')$ |

If there is no domain adverb, then the variable d' remains free (15g), with a domain value coming from the context.

This analysis explains the properties of domain adjectives that we discussed in section 3. The ‘nominal base’ in domain adjectives (*financ-ial*) corresponds to the domain identifier in the corresponding lambda term ($\lambda n. n(\mathbf{finances})$). Their type (mapping domain-to-kind functions to kinds) is such that they can not apply an entity: hence the impossibility to use them predicatively. This type is also incompatible with degree modification and it also explains why domain adjectives are closer to the noun than other adjectives: if a noun is of the type domain-to-kind, then only domain adjectives (mapping domain-to-kind functions to kinds) can directly apply to them. Furthermore, we saw in (14) and (15) how the domain parameter in the noun allows for different ways of delimiting the domain. We understand now why domain adjectives are not straightforwardly substantive: it depends on the context that specifies domain d' in (15g) whether (15f) entails (15g).

5 The wider landscape of domain adjectives

With appropriate refinements, the proposal can scale up to a much wider set of examples with domain modifiers. There are cases where metaphorical adjectives (16a) and verbs (16b) are modified that work in the same way. There are also non-metaphorical cases of various types (Rawlins, 2004), like (16c) and (16d), and idiomatic examples like (16e) (Ernst, 1981; Gehrke & McNally, 2019):

- (16) a. Emotionally, he is damaged. / He is emotionally damaged.
 b. Spiritually, she wandered. / She wandered spiritually.
 c. Politically, California is irrelevant. / California is politically irrelevant.
 d. Botanically, tomatoes are fruits. / Tomatoes are botanical fruits.

- e. Socially, he kicked the bucket. / He kicked the social bucket.

For *damaged* in (9a) and *wander* in (9c) we would have the functions λd **damaged** $\triangleright d$ and λd **wandering** $\triangleright d$, respectively, with the same adverbs working either at the nominal or at the sentential level. What this would require is a way to talk about the kinds (or concepts) corresponding to adjectives like *damage* and verbs like *wander*. In (9c) and (9d) there are no metaphorical shifts, so we would have to generalize our idea of how predicates can depend on a domain: λd **irrelevant** $\triangleright d$ and λd **fruit** $\triangleright d$ are functions that relativize the concepts of irrelevance and fruit to different domains, making it possible to specify those domains at different points in the sentence. What makes the situation in (9e) special is that the domain adjective *social* modifies a noun (*bucket*) that is part of an idiom (*kick the bucket*) for ‘die’. A loosening of the relation between form and meaning, maybe along the lines of Gehkre & McNally (2019), is necessary to allow the adjective *social* to target the domain variable of the whole idiom’s meaning (that is, λd **die** $\triangleright d$), even though it is the sister of the (meaningless) idiom part *bucket*.

Clearly, each of these types requires much more study before we can arrive at an integrated account of domain modification of different categories, with and without metaphorical shifts, with and without idiomatic structures. The analysis of domain modifiers given in this paper provides a promising starting point for such an account, because of the way it makes concepts and domains an explicit part of the semantics.

6 Conclusion

Domain adjectives with metaphorical nouns have never been properly analyzed in formal semantics. The need for such an analysis required us to take the role of domains seriously in compositional semantics. In this way, the intricate behaviour of domain adjectives received a natural account. It also opened up perspectives for a wider set of constructions with domain adjectives and domain adverbs. Moreover, giving domains their proper place in the compositional semantics allows that kind of semantics to connect to richer models of domains and metaphorical meanings, whether coming from a conceptual perspective (Gärdenfors, 2000), based on frames and mappings (like Stickers et al. 2016) or from a computational perspective, based on distributional vector spaces and transformations (Gutiérrez, Shutova, Marghetis, & Bergen, 2016). In this way, it helps us to better understand the amazing adaptability of word meanings across an open-ended space of conceptual domains.

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