Kinds, descriptions of kinds, concepts, and distributions

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Within referential approaches to meaning, Carlson's (1977) notion of kind as an entity has played an influential role not only in the analysis of generic sentences, but also in the analysis of common noun semantics within so-called "layered" approaches to the syntax and semantics of nominals (e.g. Zamparelli 2000). Within the latter approaches, two competing views of the role of kinds in the semantics of nominals have developed, neither of which is entirely satisfactory. In this paper I argue that by modeling the semantics of common nouns using distributional semantic representations and connecting them in a very specific way to an otherwise standard referential semantics, we overcome the limitations of these kind-based accounts of the semantics of common nouns while preserving their insights. Insofar as distributional representations have been proposed as ersatz conceptual representations (Lenci 2008b), the analysis also exemplifies a concrete proposal about how conceptual and referential approaches to meaning might be integrated.

1 Introduction

Carlson (1977) defended the hypothesis that natural language ontology includes not only "ordinary" (token) object-level entities such as people or artefacts but also kind-level entities, which are of the same semantic type but of a different

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sort.[1] He argued that bare plurals in English (as in (1a)), as well as some uses of definite singulars, (as in (1b)) are rigid designators that denote kind-level entities. In other words, they could be thought of as proper names for kinds.

(1) a. Snakes are reptiles.
    b. The snake is a reptile.

This hypothesis led to significant advances in the study of genericity, and though the specifics of Carlson's account of reference to kinds have subsequently been the subject of much debate (see e.g. Carlson & Pelletier 1995; Mari et al. 2013), kinds themselves have persisted in natural language ontology and have been used in the analysis of other semantic phenomena that do not involve genericity, notably in the internal semantics of nominals (e.g. Zamparelli 2000, Chierchia 1998, McNally & Boleda 2004, Déprez 2005, Espinal 2010).[2] Within this latter line of research, which will be our primary focus in this paper, all analyses start from the basic idea developed in Zamparelli 2000 that nominal expressions have a "layered" structure, as will be described in section 2, and that kinds are somehow involved in the semantics of the innermost or deepest layer. However, they divide into two main groups based on the way in which kinds are appealed to in the syntax-semantics interface: One line of analysis posits that common nouns denote kinds themselves (i.e. a subsort of entity), while the other argues that they denote descriptions of kinds (i.e. sets of (sub)kinds in an extensional set-theoretical semantics).

While this work as a whole has yielded considerable insights into natural language data, the modeling of kinds as atomic entities is rather uninformative, telling us little about what a kind actually is. Krifka (1995) suggests that kinds correspond to sortal concepts but says little about what these are. Müller-Reichau (2011), p. 46, suggests that kinds are reifications of concepts, where he understands a concept as "information in the mind that allows us to discriminate entities of [one] kind from entities of other kinds" (citing Löbner 2002:20) or "accumulated knowledge about a type of thing in the world" (citing Barsalou 2000). Note that the

[1] Carlson's ontology also included a third sort of entity, so-called stages of individuals, but these will not be relevant in the following discussion and I will say no more about them here. Hereafter I use the term "token entity" to refer to Carlson's object-level entities, but I retain Carlson's use of the marker *o* (mnemonic for "object-level") as a subscript to distinguish variables over token-level entities from variables over kind-level entities.

[2] I use the term 'nominal' as the most general label for expressions whose main descriptive content is provided by a noun. More specific terms such as NP (noun phrase) and DP (determiner phrase) will be used when relevant.

formal distinction between kinds and descriptions of kinds thus has a counterpart in the cognitively oriented literature. Both Löbner and Barsalou consider concepts and kinds as distinct: Concepts are the descriptive basis for kinds (which Löbner equates with categories, and which we might assume to be equivalent to Barslou's "type" in the quote above). However, this distinction is arguably not exactly the same one that Müller-Reichau makes: intuitively, the reification of a concept is not the same thing as a category, a point to which I return below.

Kinds thus serve as a bridge to connect referential and cognitive or conceptual approaches to meaning, and the goal of this paper is to take a very modest step onto this bridge. I will do so by proposing a way to resolve the debate about what exactly common nouns denote by appealing to recent developments in so-called distributional semantics (see Turney & Pantel 2010 and references in Section 3). This appeal is in line with recent work that seeks to use distributional representations as ersatz conceptual representations (see e.g. the papers in Lenci 2008b). The specific features of these representations and the method I sketch for connecting them to a relatively standard referential semantic analysis will overcome the limitations of previous analyses of common nouns in layered approaches to the syntax of nominals. More generally, the analysis also constitutes a concrete proposal for combining insights from referential and conceptual approaches to meaning that, while still very preliminary, I hope will promote further synergies between the two traditions.

The paper is structured as follows. In section 2, I briefly review the two main uses of kinds within nominals. Section 3 provides a brief introduction to distributional semantic representations. Finally, in section 4 I develop the idea that such representations could serve as models of common noun denotations and, very briefly, I discuss the implications for kind reference.

2 Carlsonian kinds and determiner phrase semantics

As mentioned in the introduction, Carlson's (1977) ontology included kind-level and token-level entities as primitives. He related these kinds and tokens via a realization relation, **R**: If a token entity x_o realizes a kind y_k, then $\mathbf{R}(x_o, y_k)$. By hypothesis, all token-level entities are realizations of some kind-level entity.

Carlson took common nouns to denote sets of what he called individual-level entities (the union of kind- and token-level entities, as opposed to stage-level entities), and used plurality (in the case of English bare plurals) to convert this set-type denotation into a kind-referring expression. For example, *snake* was assigned a logical translation that can be represented as in (2a), and *snakes*, as in (2b). This latter translation says that *snakes* denotes that kind-level entity all of whose token instances are snakes (see Carlson 1977:145ff,[3] non-essential details modified from the original; x_i is a variable over the union of kinds and tokens).

(2) a. snake: $\lambda x_i[\mathbf{snake}(x_i)]$
    b. snakes: $\iota x_k[\forall z_o \Box[\mathbf{R}(z_o, x_k) \rightarrow \mathbf{snake}(z_o)]$

The reader is referred to Carlson's work for the details of how this basic proposal was incorporated into a broader analysis of English.

Carlsonian kinds were given a different application in Zamparelli 2000. Zamparelli argued that full determiner phrases (DPs) have a 3-layered structure consisting of a kind phrase (KIP), a predicative determiner phrase (PDP), and a strong determiner phrase (SDP). The goal was to account for a complex array of facts involving the relation between the internal syntax and semantics of nominals and their external syntax and semantics, such as the fact that certain kinds of apparent "determiner stacking" (e.g. *the*/*every*/demonstratives + numeral) are possible. (3) provides an example of a Zamparelli-style syntactic analysis for the DP *that one child*.

(3) $[_{\text{SDP}}$ that $[_{\text{PDP}}$ one $[_{\text{KIP}}$ child]]]

We will not go into the details of Zamparelli's analysis of the SDP and PDP here. What is relevant for our purposes is his claim that all common nouns project into nominals as kind phrases and "denote individual 'kinds of objects' in the domain." (2000: ex. (436)). He then used the type-shifting operations **KO** and **KSK** to convert the kind phrase into an expression that denotes a set of token entities or subkinds, respectively (see (4) and Zamparelli 2000: ex. (461)-(462), where **KIP** stands for the logical translation of the kind phrase; other irrelevant details modified from Zamparelli's original).

(4) a. $\mathbf{KO}(\text{KIP}) : \lambda x_o[\mathbf{R}(x_o, \mathbf{KIP})]$
    b. $\mathbf{KSK}(\text{KIP}) : \lambda x_k \forall z \Box[\mathbf{R}(z, x_k) \rightarrow \mathbf{R}(z, \mathbf{KIP})]$

[3] Page numbers correspond to the version of this work published in 1980.

The output of these operations can then be the input to a higher determiner, as in (5a) and (5b), respectively: *two books* in (5a) is understood as referring to two token books (which could be of the same (sub)kind), while *two wines* in (5b) necessarily refers to two different subkinds of wine.

(5) a. Max read two books.
  b. Max produces two wines.

Curiously, Carlson's and Zamparelli's analyses of common nouns are essentially inverses of each other. Carlson takes common nouns to be fundamentally descriptions or predicates and uses syntax to convert them into referring expressions. Zamparelli takes them to be fundamentally referring expressions and uses syntax to convert them into descriptions or predicates.

One phenomenon that might be thought to distinguish between these two analyses is modification. McNally & Boleda 2004 argued that relational adjectives such as *legal* in (6a), in contrast to other adjectives, such as *clever* in (6b), denote descriptions of kinds, rather than of token entities.

(6) a. a legal adviser
  b. a clever adviser

On this analysis, *legal* and similar adjectives serve to restrict kind descriptions, thus forming subkind descriptions, which are later converted to descriptions of token entities that can be further restricted with token-entity modifiers such as *clever.* Though McNally and Boleda did not use the layered DP structure, their proposal can easily be adapted to the layered analysis, as shown in (7). The noun denotes a set of (sub)kinds (including not only the maximally general adviser kind but also legal advisers, political advisers, economic advisers, etc.), represented as in (7a). The relational adjective also denotes a set of kinds, those that stand in some relation to the law: for example, (legal) system, (legal) document, (legal) issue, as in (7b).[4] These combine at the KIP level (7c), and the result can serve as the input to a variant of the **KO** type-shifter (call it **KO′**) that, instead of taking kinds, takes

[4] McNally and Boleda treated the adjective as a first order property that combined with the noun intersectively via an *ad hoc* composition rule; here I treat it as a second order property for the sake of simplicity. The difference is not crucial.

descriptions of kinds and saturates the kind variable (7d,e).[5] The resulting property of tokens can combine (e.g. via predicate conjunction) with other token modifiers, such as *clever*, to yield descriptions such as *clever legal adviser*; see (7f,g).

(7) a. adviser: $\lambda x_k[\mathbf{adviser}(x_k)]$
b. legal: $\lambda P_k \lambda x_k[P_k(x_k) \wedge \mathbf{legal}(x_k)]$
c. $[_{\text{KIP}}$ legal adviser$]$: $\lambda x_k[\mathbf{adviser}(x_k) \wedge \mathbf{legal}(x_k)]$
d. $\mathbf{KO}'$: $\lambda P_k \lambda x_o[\mathbf{R}(x_o, y_{k_i}) \wedge P_k(y_{k_i})]$
e. $\mathbf{KO}'([_{\text{KIP}}$ legal adviser$])$:
$\lambda x_o[\mathbf{R}(x_o, y_{k_i}) \wedge \lambda x_k[\mathbf{adviser}(x_k) \wedge \mathbf{legal}(x_k)](y_{k_i})]$
$= \lambda x_o[\mathbf{R}(x_o, y_{k_i}) \wedge \mathbf{adviser}(y_{k_i}) \wedge \mathbf{legal}(y_{k_i})]$
f. clever: $\lambda P_o \lambda x_o[P_o(x_o) \wedge \mathbf{clever}(x_o)]$
g. clever legal adviser:
$\lambda x_o[\mathbf{R}(x_o, y_{k_i}) \wedge \mathbf{adviser}(y_{k_i}) \wedge \mathbf{legal}(y_{k_i}) \wedge \mathbf{clever}(x_o)]$

Note that once the type-shifter $\mathbf{KO}'$ applies, we no longer have a property of kinds; rather, we have a property of token entities. This entails that any kind-level modifiers will have to combine with the noun *before* the type-shifter. The layered structure also guarantees that any token entity modifiers will have to apply *after* the type-shifter. These constraints, as McNally and Boleda observed, lead to a natural account of the fact that relational adjectives must appear closer to the noun than other sorts of adjectives, as shown in (8):

(8) a. a clever legal adviser
b. ??a legal clever adviser

Now let us return to the main issue, which is the distinction between treating the contents of KIP as a kind-level entity vs. a description of such entities. Neither analysis is completely satisfactory. Treating nouns as kind-denoting leaves the mechanics of modification involving relational adjectives and related phenomena[6] imperfectly explained. On this hypothesis, the contents of KIP denotes an entity, which is then fed into the **KO** or **KSK** type shifter to yield a property that can

[5] This is done here indexically, following McNally and Boleda. However, it could be done by other means, such as existential closure. Another variant on this analysis involves using the functional projection Number for the purpose effected here by **KO**; see Espinal 2010, Arsenijević et al. 2014 for details of this latter alternative.

[6] See e.g. Espinal 2010 for additional examples.

eventually combine with a determiner. Let's assume, following McNally and Boleda, that the adjective in (6a) denotes a property of kinds, and let's represent the kind denoted by *adviser* as **a**. If we combine the adjective and the entity-denoting noun directly, the result is a proposition:

(9) $\mathbf{legal}(\mathbf{a})$

A proposition is not the right sort of semantic object to feed the rest of the semantic composition of the DP.

Alternatively, we could first apply the type shifter **KSK** to the kind denoted by adviser:

(10) $\mathbf{KSK}(\mathbf{a}) : \lambda x_k \forall z \Box[\mathbf{R}(z, x_k) \rightarrow \mathbf{R}(z, \mathbf{a})]$

However, this output denotes a set of kinds, not a kind, and therefore cannot serve as input to the **KO** type shifter for purposes of creating a description of token entities. While we could of course posit both **KO** and a counterpart **KO′** like that used in the alternative analysis in (7), a perfect parallelism between the derivation of *clever adviser* and *clever legal adviser* is lost. In the former case, only **KO** would apply to generate a description that could combine with *clever*; in the latter, first **KSK** and then **KO′** would apply. Not only is this inelegant: crucially, it fails to capture the fact there is no evidence that *adviser* and *legal adviser* are of distinct semantic types.

The analysis of common nouns as properties of kinds fares better on this point, insofar as it maintains a parallelism between the semantics of *adviser* and *legal adviser*. However, it has a couple of weaknesses. First, it forces the introduction of a kind variable as an ordered argument of the noun whose existence is motivated exclusively by the need to mediate modification (see McNally 2006 for more on this point). If, as (7g) suggests, the phrase *clever legal adviser* introduces a variable y_{k_i} referring to the legal adviser kind, we might expect that variable to license discourse anaphora systematically. However, such reference is not systematically felicitous, as shown in (11), in which it is very difficult to interpret they as picking out legal advisers in general (as opposed to clever legal advisers).

(11) The banker avoided jail thanks to **clever legal advisers**. **They** are usually worth the investment.

While there could be a variety of explanations for this fact, it is hardly a merit of the analysis in (7g).

A second weakness of both this analysis and Zamparelli's, as noted in the introduction, is that this appeal to kinds and kind descriptions implicitly acknowledges that not all descriptive content within the DP is fulfilling the same function: kind-level modifiers serve to create subkind descriptions – complex concepts, in Löbner's sense of concept mentioned above – while token-level modifiers simply provide additional description of the referent(s) of the DP. Our understanding of the former function is not particularly aided by a characterization grounded in a fundamentally referential semantics of the sort that Carlson used, and indeed Löbner (loc. cit.) suggests that common nouns pick out concepts. However, if indeed the layered approach is justified, it suggests that, conversely, not all descriptive material with the DP serves to form complex concepts, and therefore we do not necessarily want to abandon a referential approach to meaning entirely.

As a concrete proposal for bringing something of the spirit of conceptual semantics into a referential framework, with the specific goal of being able to model the composition of subkind descriptions in a more interesting way than is possible using standard formal semantic tools, I will appeal to distributional semantics.[7] After presenting a brief introduction to the crucial features of distributional semantics in the next section, I will then suggest a method for integrating it into the layered analysis of DPs.

3 A brief introduction to distributional semantics

Distributional semantic models vary in detail, but the sorts of models that will concern us all represent expression meanings as vectors or matrices based on co-occurrence distributions in a corpus. For example, in the study described in Boleda et al. 2013, to represent a noun, we automatically compiled the number of occurrences of that noun with each of the 10000 most frequent content words in our corpus (chosen from nouns, verbs, adjectives and adverbs), within a same-sentence window. Using these criteria, in the representation of *dog*, the count for the verb *bark*, would include the instance of bark in (12a), but not that in (12b).

[7] The terms *Latent Semantic Analysis* and *vector-space semantics* are also used for essentially this sort of approach. See Landauer & Dumais 1997 for an early discussion of the psychological interest of these representations; see Turney & Pantel 2010 and Baroni et al. 2014 for overviews of more recent developments in distributional semantics and additional background.

(12) a. The dog barked.
b. We saw the dog. It barked.

Distributional models vary in the number and kinds of expressions that are included in the vector representation, as well as in the nature and size of the window.[8] In the simplest models the co-occurrence counts follow a "bag-of-words" approach and do not take into account grammatical information: for example, in the representation of *dog*, the count for the verb *bark* would include both the co-occurrence found in the sentence *the dog barked at the child* and in *the child barked at the dog*. More sophisticated analyses (e.g. Erk & Padó 2008, Baroni & Lenci 2009) take the grammatical relations between words into account.[9]

Table 1 offers a toy example of what distributional representations might look like for the words *dog*, *cat*, *car*, and *ink*. From a simple inspection of this example it is easy to see how distributional representations roughly approximate concepts. High co-occurrence values for a given word in a vector indicate strong associations; low values indicate little or no association. Thus, the information in Table 1 suggests that there is a comparatively strong relation between dogs and fur (and cats and fur), but no relation between cars or ink and fur. Note that these representations differ sharply from logical semantic representations insofar as these associations need not be entailed. For instance, nothing in the lexical entailments for *dog*, as these are normally understood by formal semanticists, would directly include anything about chasing or running, but the distributional representation indicates some sort of relation between dogs and both running and chasing.

	fur	bark	purr	run	chase	pen
dog	53	22	0	16	29	0
cat	44	2	40	15	45	0
car	0	4	10	10	30	0
ink	0	0	0	10	0	33

Table 1: Toy distributional representations for *dog*, *cat*, *car*, and *ink*

[8] The question of how best to set such parameters is far from trivial, but fortunately it is not crucial to the point being made in this paper. I therefore will not explore it further here.

[9] Note also that typically, the information in these vectors is compressed by additional mathematical operations such as Singular Value Decomposition or Nonnegative Matrix Factorization. These details will not concern us here.

Crucial for our purposes is the fact that distributional representations for words can be combined to make distributional representations for phrases (see Mitchell & Lapata 2010, Baroni & Zamparelli 2010, Garrette et al. 2011, Coecke et al. 2011, Clarke 2012, Copestake & Herbelot 2012, Socher et al. 2012, Lewis & Steedman 2013, Grefenstette 2013, Baroni et al. 2014 and references cited in these works for various proposals and general discussion). Even more interestingly, there is a very lively debate over whether it is preferable to rely exclusively on distributional representations for modeling sentence meaning, or whether distributional semantics might be better used in combination with logical semantics, and limited to modeling only some parts of sentence semantics. One of the roots of this debate is the fact that distributional models work well for what we might loosely refer to as "content words" and short phrases made up of them, but fare rather poorly with "function" words such as determiners, auxiliary verbs, or conjunctions – that is, those expressions that referential semantic approaches handle well. These and other considerations will lead us to use a combination of distributional and formal modeling in the next section.

Before moving on, however, let me briefly illustrate semantic composition with distributional representations so that the potential for improvement over the analyses presented in the previous section becomes apparent. One finds significant variation not only in the operations used to combine vector, for words but also in other parameters, such as whether specific values in the operations should be weighted. Here we will limit ourselves to using the simplest method, namely vector addition, to illustrate. Table 2 presents a toy model of how the vectors for two words can be added to yield a vector representation for a phrase.

	bright	irritated	burn	stop	warn	apple
red	99	20	40	98	29	15
flag	19	2	1	50	45	0
skin	6	90	79	8	2	15
red flag	118	22	41	148	74	15
red skin	105	119	119	106	31	30

Table 2: Semantic composition modeled by vector addition

What can be observed is that when two words share high values for a given co-occurrence item in the vector (e.g. *stop* in the case of *red* and *flag*), the association between that item and the resulting phrase is proportionally strengthened – for example, the association between *stop* and *red flag* is stronger than that for *stop* and *red.* Conversely, when two words share low values for some item, the corresponding value for the resulting phrase is proportionally weakened. When the values on an item for individual words go in opposite directions (e.g. *bright* for *red* and *skin*), the value for the result lies somewhere in between.

The quality of distributional representations as models of meaning can be evaluated in at least two different ways. First, since vector representations fundamentally encode similarity relations, one can measure the similarity between words or phrases as determined by the model against human judgments of similarity. One specific measure of similarity is the cosine between the vector for a word or phrase of interest and that of some target: a cosine of 0 indicates orthogonality, i.e. high dissimilarity; the higher the cosine, the greater the similarity. Another measure is the quality of the so-called nearest neighbors of a vector for an expression matched against human judgments. The nearest neighbors of a vector v are those vectors with the largest cosine values with respect to v. Thus, vectors that are nearest neighbors are very similar, and we would expect the expressions they represent to be judged as very similar by humans. Table 3 offers an example (larger numbers of neighbors than just 3 could of course also be evaluated). Note that nearest neighbors need not be of the same grammatical category; it is also relevant to consider not only the quality of the nearest neighbors but also their density, that is, their absolute distance from the vector of interest and from each other.

historical map	*important route*
topographical	important transport
atlas	important road
historical material	major road

Table 3: The 3 nearest neighbors of the corpus-derived distributional vectors of two ANs (from Baroni and Zamparelli 2010), cited in Table 4 of Baroni et al. 2014.

A second way to evaluate the quality of distributional representations is to test them on a specific task, such as the analogical reasoning tasks given on the SAT exam (see Turney & Pantel 2010 for examples). The fact that machines using distributional representations are currently able to perform at levels comparable to humans on such tasks suggests that the representations are at least in some sense a meaningful model of human semantic knowledge.

Distributional representations for words, as well as operations such as vector addition for combining them, have a number of interesting features for the modeling of certain aspects of semantic composition in natural language that are not shared by logical models. Perhaps the most important one is that they are relatively successful at handling the resolution of polysemy and co-composition-type phenomena (Pustejovsky 1995), particularly for small phrases and generic contents (Boleda et al. 2013, McNally & Boleda to appear). They also offer the possibility of modeling metaphor (e.g. Kintsch 2000, Lemaire & Bianco 2003, Utsumi 2006). The fact that distributional representations can be constructed using exactly the same method for both words and phrases in a sense blurs the line between word and phrase, suggesting an interesting avenue for exploring the origins and nature of idiomatic expressions. Finally, as noted above, these representations make no sharp distinction between "linguistic meaning" and world knowledge; depending on one's view of meaning, this is a bug or a feature. In addition to these theoretically relevant properties, they have the practical advantage of being very easy to build automatically for very large lexicons.

However, distributional models also have limitations beyond their poor handling of function words mentioned above. First, it is not obvious how to model phenomena grounded in reference and discourse dynamics, such as anaphora or information structure. Second, at present distributional models say little or nothing about how to capture mid-level semantic generalizations of the sort that are embodied in approaches that posit semantic features for causation, change, agentivity, etc. Third, it is not obvious how these models can account for most patterns of entailment and logical inference, particularly those based on the behavior of logical connectives such as conjunction, disjunction, or negation. For a review of all of these issues, see Baroni et al. 2014. Finally, there is some question as to the adequacy of distributional representations as models for language acquisition (Lenci 2008a, Copestake & Herbelot 2012, though see also Landauer & Dumais 1997). Though these limitations are daunting, distributional models are an active area of research and efforts are under way to overcome them or, as will be done here, to find an optimal division of labor between distributional and formal modeling (see Kamp et al. 2013 and references cited therein).

4 Distributional representations as alternatives to kinds and kind descriptions

With this brief introduction to distributional semantics in hand, let us return to the focus of the paper, namely, if we accept the layered DP hypothesis, how do we analyze the noun at the heart of the DP so as to avoid the weaknesses both of the kind-as-entity and the kind-description accounts? Recall the problems: If kinds are treated as entities, it is not obvious how to handle modification processes that produce expressions picking out subkinds. On the other hand, if we treat nouns as kind descriptions we end up introducing a variable into the syntax, corresponding to the kind that is described, whose existence is not otherwise motivated. Moreover, on both accounts, the notions of kind and kind description are rather poor.

Let us suppose that we treat common nouns as denoting distributional representations (or sometimes I will use simply *distributions* for short).[10] In other words, we use distributional representations instead of Carlsonian kinds or kind-descriptions, the intuitions being 1) that the distributional representation serves as a convenient way of modeling a concept and 2) kinds have been used, for better or for worse, as the referential semantics counterpart to concepts (more on this latter point below). Distributions will be represented in the logical translations by constants with an arrow over them, as in (13a), to distinguish them from constants that refer to ordinary entities; following Espinal 2010, I will refer to the lowest layer of the nominal where nouns are inserted as NP, rather than KIP. I will use Number as the functional projection that contributes the type shifter **KO′**, which creates properties of token entities, as in (13b), where the definition of the type shifter and the realization relation **R** are revised to select for distributions rather than kinds (i.e., dr is the variable over distributions). The **R** relation holds between an entity and a distribution (understood here as standing in for a concept) just in case the entity in question is taken as an instance or exemplar of that concept. If we combine a simple noun such as *adviser* with **KO′**, the result is a predicate of token entities, as in (13c).

(13) a. $[_{\text{NP}}$ adviser$]$: $\overrightarrow{\textbf{adviser}}$
 b. $[_{\text{Num}}$ **KO′**$]$: $\lambda dr \lambda x_o[\mathbf{R}(x_o, dr)]$
 c. $[_{\text{NumP}}$ **KO′**$[_{\text{NP}}$ adviser$]]$: $\lambda x_o[\mathbf{R}(x_o, \overrightarrow{\textbf{adviser}})]$

[10] The expression "denotes a…representation" should not raise any concern, insofar as these representations are mathematical objects and not translations of natural language into some other representational language that then needs to be interpreted.

Let us further assume a parallel analysis for adjectives. We have seen that (McNally & Boleda 2004) argued that adjectives, like nouns, must be able to denote properties of kinds, in addition, in most cases, to being able to denote properties of token entities. We can therefore hypothesize that adjectives also denote distributional representations and can be converted into properties of token entities in combination with functional structure in the morphosyntax. This functional structure will be different from that which is relevant for nouns (e.g. Number, as suggested in footnote 5), insofar as adjectives typically do not have the same function in language as do nouns. For example, one candidate might be Agr(eement) (see e.g. Cinque 2005), and indeed this is what I will assume here for the sake of illustration.

I will also assume a second difference between adjectives and nouns. Instead of introducing the realization relation **R**, I take the adjective's functional structure to introduce a bearer relation (represented in (14) as **Bear**) between the distributional representation and the individuals to which it is ascribed, as illustrated in the logical translation in (14) for the adjective *clever*. I take the bearer relation to be distinct from the realization relation insofar as when an individual stands in the former relation to some concept, that concept will be manifest in that individual without serving as a criterion for identifying the individual; when an individual stands in the latter relation to some concept, that concept can be said to be both manifest in the individual and to serve as a criterion for indentity.[11]

(14) a. $[_{\text{AP}}$ clever$]$: $\overrightarrow{\textbf{clever}}$
   b. Agr: $\lambda dr \lambda x_o[\textbf{Bear}(x_o, dr)]$
   c. $[_{\text{AgrP}}$ Agr $[_{\text{AP}}$ clever$]]$: $\lambda x_o[\textbf{Bear}(x_o, \overrightarrow{\textbf{clever}})]$

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[11] On this view, adjectives and nouns, as represented in the lexicon, differ only in the sorts of concepts that they represent. We might therefore expect an expression like *clever* to be able to combine with functional structure like Number to make a description that serves to identify individuals. Indeed, this sort of thing is possible, as illustrated in English examples in (i) from Glass (2014) and the Dutch ones in (ii) from McNally & de Swart (2015), though its nature and productivity vary from language to language.

(i) a. In Tacloban, **the dead** are being taken to a mass grave in a public cemetery.
  b. "progress" always seems to go in one direction — toward **the dead** and **the dull**.

(ii) a. *Hoe leer je een kind dat het niet met* ***een vreemde*** *mee mag gaan?*
  how teach you a child that it not with a strange with may go
  'How do you teach a child not to leave with a stranger?'
  b. *Ze moeten wennen aan* ***al het nieuwe, al het vreemde*** *dat dit land hen biedt.*
  they must get-used to all the new all the strange that this land them offers
  'They must get used to everything new, everything strange that this land offers them.'

See McNally & de Swart 2015 and references cited there for more general discussion of the syntax and semantics of such constructions.

With these elements in hand, we can now develop an analysis of modification at the NP level that distinguishes it from modification above NP and that overcomes the problems faced by the analyses in section 2. We now have as the basic denotation for nouns and adjectives saturated, concept- or kind-description-like objects for which interesting compositional rules, such as the vector addition illustrated in the previous section, are defined. We need only posit that semantic composition within the NP involves not functor-argument application or predicate conjunction, but rather vector addition (or whatever vector compositional method eventually proves to be most effective). The result of this operation will a new vector – that is, an object of the same semantic type as the noun. Specifically, we can revise the first step of the derivation (7) as in (15), where + stands for the composition operation that combines two distributional representations, e.g. vector addition.

(15) a. $[_{\text{NP}}$ adviser$]$: $\overrightarrow{\textbf{adviser}}$
  b. $[_{\text{NP}}$ legal$]$: $\overrightarrow{\textbf{legal}}$
  c. $[_{\text{NP}}$ legal adviser$]$: $+(\overrightarrow{\textbf{legal}}, \overrightarrow{\textbf{adviser}})$

We therefore maintain a uniform analysis of all expressions in the NP category, whether simple or complex, improving upon the kind analysis of common nouns. We also avoid any appeal to variables that do not have any motivation beyond mediating in semantic composition, thus improving upon the kind-description analysis.

Exactly like simple nouns, complex NPs such as that in (15c) can be turned into predicates of token entities via the $\mathbf{KO}'$ type shifter, as in (16a). At this point, an adjective phrase that has also been converted to a predicate of token entities as in (14) can be conjoined with it in the usual fashion used for modification in formal semantics. In this way, it is possible to derive an analysis of phrases like *clever legal adviser* that distinguishes two kinds of adjectival modification, as in (16b,c).

(16) a. $[_{\text{NumP}}$ $\mathbf{KO}'[_{\text{NP}}$ legal adviser$]]$: $\lambda x_o[\mathbf{R}(x_o, +(\overrightarrow{\textbf{legal}}, \overrightarrow{\textbf{adviser}}))]$
  b. $[_{\text{AgrP}}$ Agr $[_{\text{AP}}$ clever$]]$: $\lambda x_o[\mathbf{Bear}(x_o, \overrightarrow{\textbf{clever}})]$
  c. $[_{\text{NumP}}[_{\text{AgrP}}$ Agr $[_{\text{AP}}$ clever$]]$ $[_{\text{NumP}}$ $\mathbf{KO}'[_{\text{NP}}$ legal adviser$]]]$:
  $\lambda x_o[\mathbf{R}(x_o, +(\overrightarrow{\textbf{legal}}, \overrightarrow{\textbf{adviser}})) \wedge \mathbf{Bear}(x_o, \overrightarrow{\textbf{clever}})]$

The use of distributional representations to model common noun and adjective denotations has some additional advantages. I close this section by briefly mentioning three of these.

First, the use of these representations allows for the integration into formally-oriented semantic analysis of techniques for handling the problems of polysemy in modification and other phenomena involving the lexicon that are poorly handled by traditional formal semantic tools. This integration can improve the empirical coverage of existing formal semantic theories and yield models that are better suited to natural language processing.[12]

Second, distributional models arguably come closer to capturing the intuition that common nouns and adjectives name concepts, and thus establish a point of connection to conceptual approaches to meaning. Having a richer model of what words and phrases describe than that provided by kinds or descriptions of kinds brings formal semantics, with its emphasis on reference, closer to that sector of cognitive science that is concerned with conceptual representation. Indeed, conceptually oriented semantic theories have arguably attracted much more attention from cognitive scientists than have referential theories precisely because they focus specifically on the cognitive component of meaning; referential theories have largely failed in this respect.

On the other hand, conceptual and cognitive approaches to meaning representation (e.g. Frame Semantics, Fillmore & Baker 2010) have met resistance from formally-oriented semanticists both because of concerns about how to ground the representations and because of skepticism about implementability on a large scale. Though distributional models as described here are still highly inadequate as models of concepts, they can be augmented, e.g. by incorporating image information (see e.g. Andrews et al. 2014), and the ease with which they can be constructed and implemented makes them useful as a methodological tool. Mixed conceptual and referential approaches are also arguably less susceptible to concerns about grounding.

Finally, integrating distributional representations into a formal semantics via a specific hypothesis about the syntax/semantics interface allows us to return to and address in a clearer way an issue alluded to in the introduction. I noted that Müller-Reichau 2011 proposes that kinds are the reification of concepts, while the view of Barsalou 2000 and Löbner 2002 seems to be that kinds are categories of entities that are established based on conceptual information. If we now ask ourselves what kind terms such as *snakes* or *the snake* in (1), repeated in (17), denote, we can consider at least two explicit hypotheses.

[12] See especially Garrette et al. 2011, Copestake & Herbelot 2012, Lewis & Steedman 2013, Kamp et al. 2013, Erk 2016, and Baroni et al. 2014 for discussion and examples.

(17) a. Snakes are reptiles.
 b. The snake is a reptile.

Following Müller-Reichau, a kind term should arguably have a representation such as the following, picking out the unique distributional representation – the concept – associated with *snake*.

(18) $\iota dr[dr = \overrightarrow{\textbf{snake}}]$

In other words, when we use *the snake* generically, we are referring to the snake concept, rather than to any class of individuals that it might serve to individuate. If we maintain the analysis of common nouns developed in the previous section, this would also be the predicted denotation for definite kind terms if we accept the syntactic analysis of them defended in Espinal 2010, where (based on independent considerations) such DPs are assigned a syntax in which Number does not intervene:

(19) $[_{\text{DP}}\ [_{\text{D}'}$ the $[_{\text{NP}}$ snake$]]$

Interestingly, this is more explicit than the semantics that emerges from Espinal's proposal, which is based on the premise that common nouns denote descriptions of kinds. The representation for the semantics of (19) given her assumptions would thus be as in (20):

(20) $\iota x_k[\textbf{snake}(x_k)]$

Whether this is substantively equivalent to (19) of course depends on whether kinds are equivalent to concepts or not, an issue that the formal literature has done a notoriously poor job of addressing (see e.g. the discussion in Müller-Reichau 2011, Chapter 3). One advantage of the introduction of distributional representations is that it forces one to address precisely this issue.

On the other view, where concepts serve to support categorization of entities as belonging to one kind or another, the notion of kind or category is not the reification of a concept. As a result, whatever semantics we assign to the kind terms in (17), it should not be that in (19). For example, we might consider the sort of proposal advocated in Chierchia 1998, on which kinds are conceived of as "regularities that occur in nature...similar to individuals like you and me, but [whose] spatiotemporal manifestations are typically 'discontinuous"' (p. 348). Formally, Chierchia models kinds as “individual concepts of a certain sort: functions from worlds (or situations) into pluralities, the sum of all instances of the kind” (p. 349). Implemented in the system proposed here, a first attempt a such a semantics for *the snake* would look as follows:

(21) $[_{\text{DP}}\ [_{\text{D}'}$ the $[_{\text{NumP}}$ snake]]: $\lambda w[\mathbf{max}x_o[\mathbf{R}_w(x_o, \overrightarrow{\mathbf{snake}})]]$

If we assume that x_o ranges over both singular (atomic) and plural (nonatomic) entities, the result is very close but not identical to what Chierchia proposes. Interestingly, he adds a slight refinement on which the sum identified by the equivalent of $\mathbf{max}x_o[\mathbf{R}(x_o, \overrightarrow{\mathbf{snake}})]$ is converted into an atomic group whose members are not accessible for compositional semantic purposes (Landman 1989a, 1989b). In other words, he essentially reifies the class of entities picked out by (21). However, on what morphological basis this additional reification is motivated is not clear.

Though this is not the place to decide what is, in fact, the best analysis of the different sorts of nominals that appear in generic sentences,[13] this brief discussion has allowed us to model two different possibilities in an explicit and easily distinguishable fashion. This is arguably an improvement over the previous situation, in which the use of the same formal object, namely kinds, both to model common noun denotations (whether directly, or indirectly via descriptions of kinds) as well as to model the denotations of DPs such as *the snake*, hampered the identification of relevant differences between different proposals. Given the semantics for common nouns advocated here, the analysis on which kind terms such as *the snake* refer to the concepts themselves, rather than to the class of entities identified by the concept, is derived more naturally from the syntactic structure. To the extent that this result might seem prima facie counterintuitive, the implications for the analysis of generic sentences as well as for so-called kind-referring predicates such as *to be extinct* are non-trivial.

[13] It should also be noted in passing that both Chierchia and Espinal suggest analyses for bare plurals in English that are distinct from the analyses they defend for general definite singulars; I set aside bare plurals because a proper treatment of them would take us too far afield.

5 Conclusion

The linguistic salience of something like Carlsonian kinds has been amply supported in the formal linguistics literature, as has the idea that DPs have a layered structure in which kinds or descriptions of them serve as the semantic core. I have argued here that distributional representations have potential to serve as models for the semantics of this lowest layer, with the advantage that there are explicit compositional mechanisms for combining them that make interesting and testable predictions, and that they avoid using otherwise unmotivated variables in the composition process. I have also very briefly sketched how these representations could be integrated into a more standard compositional semantic framework.

Though the paper has focused on layered DPs, it is possible to imagine extending the analysis advocated here to other linguistic categories. Within what Borer 2003 refers to as "exo-skeletal" approaches to morphosyntax, such as Distributed Morphology (Halle & Marantz 1993; see Borer 2003 for additional references to related work), the open-class lexicon consists of:

> ...sound-meaning pairs, where by meaning we refer to the appropriate notion of a concept, and where by sound we mean an appropriately abstract phonological representation. Following tradition, I will refer to that reservoir as the encyclopedia, and to items within it as encyclopedic items (EIs). Crucially, an EI is not associated with any formal grammatical information concerning category, argument structure, or word-formation. It is a category-less, argument-less concept, although its meaning might give rise to certain expectations for a felicitous context... (Borer 2003, p. 34)

These lexical items combine with other, possibly abstract, morphemes in the lexicon that contribute functional material (e.g. plural morphology, tense) that convert them into categorized expressions – full-fledged nouns or verbs, for example.

The similarities to the layered DP hypothesis are obvious, and in particular, the idea that these category-less encyclopedic items are paired with concepts looks very much like the idea we have developed in the previous section. We might therefore consider extending distributional representations to model the denotations of roots more generally. But that is a task for another paper.

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