Family Resemblances, Radial Networks, and Multidimensional Models of Meaning
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Abstract

Prototype-based studies of lexical semantic structure employ various forms of descriptive representation: a family resemblance structure of overlapping sets, a radial network model, a schematic network model, and a multidimensional model. The present paper explores the relationships between these various form of representation. It argues that the basic distinction between the representational models involves the focus they lay on either of two fundamental features of prototypicality: salience effects among the members of the category, or the absence of classical definability.

1. Representational formats in prototype theory

Prototype models of lexical meaning as commonly applied in linguistic semantics tend to use a number of apparently diverging representational formats. First, the family resemblance model describes the structure of a category in terms of overlapping partial definitions. This model, which was first described theoretically by Wittgenstein (1953), may be found in the work of Bartsch (1985), and, in my own research, in Geeraerts (1989) and Geeraerts, Grondelaers and Bakema (1994). Second, the radial network model (and its hierarchical counterpart, the schematic network model) starts from the links that exist between the individual instances of a category. The radial network model was first applied by Brugman (1981) and popularized by Lakoff (1987); in my own research, it is represented in chapter 2 of Geeraerts (1997). For the hierarchical network model, introduced by Langacker (1987), see Tuggy (1993). The multidimensional model describes lexical structure in terms of a set of interacting dimensions. First applied by Labov (1973), it is represented in my own work in chapters 3 and 7 of Geeraerts (2006) and in Peirsman and Geeraerts (2006).

The relationship between these various forms of representation has not been the subject of much analysis. In this paper (which may be considered a sequel to Geeraerts 1995), I will show that there are systematic relations between the various formats: although they focus on different aspects of non-classical semantic structure, they appear to be complementary rather than conflicting.

2. A classical conception of semantic structure

A classical conception of semantic structure (the kind of conception that would be implicit in most structuralist conceptions of meanings) assumes the presence of two crucial features: first, the idea that meanings can be defined by means of a clear-cut definition, and second, the idea that all the things that fall within that definition basically have the same status. Each of these characteristic deserves a closer look.
First, when a dictionary defines the most common reading of *fruit* as "the edible product of a tree, shrub, or other plant, consisting of the seed and its envelope", the assumption is that this definitional description applies to all members of the category in question (all types of fruit, basically), and only to those. A definition, in other words, has to be general and distinctive: general to the extent that it applies indiscriminately to all cases of fruit, and distinctive to the extent that it does not include cases that cannot be characterized as fruit. We will discuss in a moment to what extent the definition (which is based on the New Shorter Oxford English Dictionary - further details will follow presently) actually conforms to that ideal, but at this point, it is primarily important to understand the ideal as such: for each distinct sense of a linguistic expression, there is a definition that is general and distinctive.

Second, all the cases that fall within the boundary of the definition are equally important: as representatives of fruit, any type of fruit is just as good as any other type. As far as the essence of fruit is concerned, the pomegranate is as good a case in point as the apple. Now, in a Western culture, apples are more common than pomegranates, and in that respect, it might seem relevant to say that the apple has a different structural status than the pomegranate. However, such differences would traditionally be considered differences that belong to the level of world knowledge rather than to the level of the language. From a linguistic point of view (a classical conception would say) all types of fruit are equal in semantic significance with regard to *fruit*; any differences that exist among them would be encyclopedic differences, not semantic ones.

**Figure 1. A classical conception of semantic structure**

In Figure 1, this classical view is graphically represented in a set-theoretical way: the dots represent the members of the category corresponding to the sense under investigation, and the circle represents the definition that demarcates the category. Symbolically, the definitional circle is a sharply drawn line, and the dots that stand for the instances each have the same weight within the graphical representation.
3. Family resemblances

Now, the basic assertion of prototype theory as it developed in linguistic semantics since the mid 1980s concerns the impossibility of maintaining these two classical features of semantic structure. First, it is not always possible to find a definition that conforms to the classical ideal. Concepts cannot always be defined by means of a unitary, uniquely delineating definition: some concepts are definitionally vague. We may have a closer look at the definition of *fruit* to appreciate the difficulties of defining according to the classical model.

The definition that was mentioned above, “the edible product of a tree, shrub, or other plant, consisting of the seed and its envelope”, erroneously includes nuts and grains (and some spices, and some vegetables, like eggplants) into the definition of *fruit*: nuts are the edible seed-bearing product of a tree or shrub, but they do not count as fruit. Conversely, the definition erroneously excludes rhubarb, which is considered a fruit but which does not specifically consist of the seed-bearing part of a plant.

This pattern of mistakes recurs when we consider alternative, more refined versions of the definition. Suppose we say that a fruit is “the edible seed-bearing part of a wood-plant”, where we contrast wood-plants like trees and shrubs with herbaceous plants: the vegetables that we want to exclude from the range of *fruit*, like eggplants, typically grow on herbaceous plants. However, the new definition would still erroneously include nuts, and it would erroneously exclude strawberries and raspberries and the like. So we cannot really add the restriction to wood-plants. Suppose then that we add another restriction: a fruit is “the edible seed-bearing part of a plant to the extent that it is juicy and sweet”. Again, this erroneously includes vegetables like the eggplant, and erroneously excludes bona fide fruits like lemons (not really sweet) and bananas (not really juicy). Similar problems arise if we were to say that a fruit is “the edible seed-bearing part of a plant to the extent that it may be eaten as a dessert”. This again includes nuts, and excludes fruits like the lemon, which are not typically taken for dessert.

The definitional problems are further enhanced by demarcation problems at the edges of a category. The classical approach presupposes that the set of members of a category is well known: if we cannot be sure which things go into the category that we are trying to define, how could we define it according to the classical model? Because the classical model requires that a definition holds for all the instances of a category and only those, we will have to be certain about the instances of the category before we can test the validity of our definitions. However, in quite a number of cases, questions about the boundary of a category arise: is a coconut a fruit? And the avocado? Coconuts are not exactly typical fruits, but neither are they (from a Western perspective) typical nuts: they seem to fall somewhere in between both categories. And avocados in a similar vein: they aren't exactly vegetables (you don't usually cook them, for instance), but neither do they typically taste like fruit.

The effect of these two observations may be graphically represented as in Figure 2. On the one hand, the firm boundary line that we introduced in Figure 1 is replaced by a dotted line, symbolically indicating the absence of a classical definition. What we get instead of such a classical definition is a cluster of partial definitions. The circles that are now drawn inside the original circle represent the features, or set of features, that various types of fruit share: some of them grow on wood-plants, some of them are juicy and sweet, some of them are typically eaten for dessert, but these subsets do not coincide. They do overlap, however, and this
overlapping structure is known as a *family resemblance* model: like the members of a family, the instances of the category share different sets of features from a common pool, but there is no single set of those features that is shared by all the members of the family and that neatly distinguishes them from all other families.

Figure 2. A family resemblance conception of semantic structure

Having established that a classical definition of *fruit* is not obvious, we should do full justice to the New Shorter Oxford English Dictionary. The complete text of the definition on which we based our starting-point reads like this: "The edible product of a tree, shrub, or other plant, consisting of the seed and its envelope, esp. when sweet, juicy, and pulpy. Also loosely, another sweet juicy part of a plant, as the stalks of rhubarb, eaten similarly". Contrary to expectation, perhaps, the dictionary does not conform to the classical model of meaning and definition, but rather presents a definition that uses a number of tricks to render the flexibility of meaning that we were able to observe: a restrictive hedge like *especially* on the one hand, and an expanding hedge like *loosely* on the other. That is to say, the definitional problems that a theoretically oriented analysis may reveal are far from unknown to the practical lexicographer.

4. Membership salience

But a prototype-based conception of semantic structures addresses the second feature of the classical view just as much as the first feature: not only can it be established that classical definitions are not always available for natural language meanings, but also, the members of a category do not all have the same status. Up to a point, this conclusion might be derived from the demarcational problems that were mentioned earlier: if the membership of certain entities is not entirely clear, then membership in a category would seem to be a graded phenomenon. But would the same apply if we look at the unquestionable cases? If some instances are very bad examples of a certain category (to the extent that we start doubting whether they actually belong to the category), could there also be very good examples?

It is one of the basic tenets of prototype theory that this is indeed the case: some entities that fall within the range of application of given concept occupy a more central position within that concept than others. The centrality is a
psychological one, to the extent that some cases come to mind more easily than others: if we ask a person with a Western background to name types of fruit, the apple is more likely to come up as an answer than the pomegranate. This is to some extent an effect of familiarity pure and simple, but there is also a structural aspect involved: the instances that come out as central are usually the ones that combine a majority of the characteristics that feature in the definitional family resemblance structure.

Table 1 illustrates the phenomenon for the category fruit: in the apple, more relevant features join together than in the other types of fruit. Figure 3 translates this insight into the graphical representation that we have been using as a guiding line. The observation that not all instances of a concept are equally salient but that rather, some are structurally more important than others is expressed by a difference in shading of the dots that represent the different cases.

Table 1. Centrality of instances in the category fruit  

<table>
<thead>
<tr>
<th></th>
<th>apple</th>
<th>strawberry</th>
<th>banana</th>
<th>lemon</th>
</tr>
</thead>
<tbody>
<tr>
<td>edible seed-bearing part of a plant</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>of a wood-plant</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>sweet</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>juicy</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>used for dessert</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Clearly, a definitional family resemblance cluster as represented by the solid circles in Figure 2 may be projected onto the representation in Figure 3. Against the background of Table 1, however, it becomes clear that such a projection may take different forms: each subset that we delineate may be defined by a single feature, or by a cluster of co-extensive features. In the first case, each feature of the set “edible seed-bearing part of a plant”, “of a wood-plant”, “sweet”, “juicy”, “used for dessert” (that is to say, each row of Table 1) demarcates its own set of instances; the salient cases of the category will then be found in the area where these subsets exhibit maximal overlap. This is the form of representation that is used extensively in Geeraerts, Grondelaers and Bakema (1994). In the second case, clusters of features as defined by the columns in Table 1 determine subsets; all the salient cases may then be united into the single subset defined by the column with the five pluses in Table 1. The distinction between the two methods of projecting family resemblance subsets onto the representation of salience effects may seem unimportant, but we will see in section 5 that it plays a role in understanding the concept of hierarchical network.
5. Radial sets and hierarchical networks

When it is recognized that not all instances of a category are equally salient but that some are structurally more important than others, the structural links between the entities need to be described in more detail, i.e. they may be described in qualitative terms and not just from a quantitative perspective. This is what a radial network model tries to achieve: it describes a category structure in which a central case of the category radiates towards novel instances. Less central instances of a category are extended from the center by means of conceptual mechanisms like metaphor, metonymy, similarity, specialization or generalization (the mechanisms, in other words, that are well known from traditional diachronic semantics). In the fruit example discussed so far, the relations between the individual cases are based on similarity and specialization, but if we broaden the perspective beyond the most direct reading of fruit, the senses illustrated by expressions like the fruits of the womb or the fruit of his work require other relational links. Figure 4 shows how a radial network analysis can be mapped onto the structure that we defined earlier.

In the literature on network representations of semantic structure, the
hierarchical (or schematic) network model constitutes a further development of the radial network model. The addition to the basic network model consists of the idea that the dynamism of meaning may also involve a shift along a taxonomical dimension. For instance, we can think of birds at different levels of conceptual abstraction (or schematicity, as it is also called). At one level, we have a prototypical idea of birds as living beings that have feathers and wings and that can fly. If we stay on this level, we can move from the central cases (like robins and sparrows) to peripheral cases, like birds without feathers and wings. But there are other levels at which you can think of birds: more specific ones (as when you think about individual birds, like your great-uncle’s parrot) and more general ones (like when you group bird species into categories like ‘fowl’, ‘birds of prey’, ‘water birds’ etc.).

Figure 5. A schematic network for fruit

If we apply this idea to our analysis of fruit in Table 1, the different levels of abstraction would correspond to different numbers of combined definitional features: the schemas at the more abstract levels are constituted by less features than at the more concrete ones. Following the graphical format that is usually adopted by proponents of hierarchical networks, a possible schematic network for fruit (or at least, for the few cases of fruit that we considered) could take the form of Figure 5. The vertical arrows indicate that a lower-level entity is an instantiation of a higher-level one; the thickness of the boxes indicates the relative degree of salience of the schemas. On each of the hierarchical levels, we can have horizontal links between the entities on that level, as represented in Figure 4 for the lowest level. These horizontal lines have not been drawn in Figure 5. Also, not all possible schematic levels are included: the lower level boxes invoke clusters of four or five definitional features, but the bundle with three features (corresponding with lemon) is not included, in order not to clutter the figure.
The relationship between the hierarchic network model and our earlier discussion of subsets will now be clear: the schematic higher-level entities correspond with specific combinations of definitional features, of the type we mentioned above as the second method of projecting a family resemblance structure onto a salience structure. Therefore, if each of the circles in Figure 6 stands for a bundle of definitional features, a graphical representation of the type illustrated by Figure 6 is equivalent to a graphical representation of the type exemplified by Figure 5. (To avoid misunderstandings, let it be noted that Figure 6 is not a direct rendering of Table 1 or Figure 5. Like most of the other figures, Figure 6 represents a representational format rather than an actual example.)

6. Multidimensional structures

The step towards a multidimensional model of meaning can be taken when we realize that the internal structure of concepts does not just take the form of links between the individual instances: in a number of cases, the structure involves underlying dimensions along which the individual instances systematically vary. In the fruit example, being produced by a wood-plant is a binary, categorical feature, but sweetness, juiciness, and typical usage as a dessert are graded, continuous characteristics, which could have many values on the relevant dimension.

In Figure 7, the notion of multidimensionality is illustrated by drawing three underlying dimensions, represented by solid lines. The dotted lines show how each of the instances of the category may be projected onto the dimensions. Each member of the category, in other words, may be defined as a combination of values on the underlying dimensions.
Clearly, there is a limit to the number of dimensions that can be conveniently incorporated into a single graphical representation, but it is obviously interesting to represent a structure with three underlying dimensions in a three-dimensional format, as in Figure 8. For more complex forms of multidimensionality, more mathematical forms of representation have to be used.

This representation may obviously be combined with others that we have considered: as Figure 9 shows, it is possible to combine a 3D representation of a multidimensional structure with the basics of a radial representation (to the extent that the relationship between the various instances of a category is indicated by direct links between those instances) and with the basics of a family resemblance.
representation (to the extent that the more or less salient subsets of instances are demarcated). Both parts of Figure 9 may be combined into a single representation.

Figure 9. Radial networks and family resemblances within a 3D representation

7. The relationship between the various models

How should one choose between the various representational models? Figure 6 and Figure 9 show convincingly that there is no a priori incompatibility between the various forms of representation. At least from a representational point of view, the different aspects of semantic structure that are variously highlighted by the models may be combined. This graphical compatibility reflects a descriptive compatibility. The diverse aspects of semantic structure that the various models focus on (absence of classical definability, difference of salience between instances of a category, conceptual links between different readings, an underlying structure of continuous dimensions), may occur together in a single lexical item or other linguistic expression.

This implies that the choice for one approach rather than the other depends primarily on the specific empirical characteristics of the expressions to be described: it is not necessary to single out one particular form of representation as the uniquely relevant one, but the specifics of the expressions to be described dictate which format is best. At the same time, the existence of a whole spectrum of representational templates contains a warning with regard to the descriptive segment of the research: if a certain form of representation is simply chosen as a point of departure, the descriptive scope of the study may be artificially narrowed by the implicit focus of that format. For instance, adopting a radial network model that focuses on the individual links between instances may tend to conceal the multidimensional structure of underlying components that cross-cuts the entire set of instances. The existence of different forms of representation, then, should be a permanent stimulus to pay attention to the various empirical features that the formats highlight.
References


