Introduction

Categories are the basic elements of human cognition; they “are the glue that hold our mental world together” (Murphy 2004).

Different theories of categorization:

1. The classical view
2. The prototype view
3. The exemplar view

The classical view

In the classical view, categories are defined by necessary and sufficient features.

Example: What is a square?

- It is a closed, flat figure.
- It has four sides.
- All sides are equal in length.
- All interior angles are equal.
Problems of the classical approach

- It is often difficult to decide which features to include on the list of necessary and sufficient features.
- Some categories have fuzzy boundaries.
- Some categories refer to entities that are related to each other by *family resemblance*.

Labov 1975
The prototype view

The prototype approach was developed by the American psychologist Eleanor Rosch. She conducted a series of experiments in which subjects were asked the following questions:

1. Decide for each of the following categories if it is a vehicle:
   (i) train, (ii) bike, (iii) car, (iv) boat, (v) truck.

2. Is a chicken a typical bird? Is a sparrow a typical bird? etc.

3. Indicate on a seven-point scale how well the following words represent the category fruit: (i) orange, (ii) lemon, (iii) apple, (iv) peach, (v) pear, (vi) melon.
The answers to these questions suggested that categories are organized around a best example, which Rosch called a “prototype”.

*Figure 5.1 Birdiness rankings*
Categories are culture-specific

Tables/desks

Cars

![Cars](images/cars.jpg)
Categories are context-dependent

1. The hunter took his gun, left the lodge and called his dog.
2. Right from the start of the race the dog began chasing the rabbit.
3. She took her dog to the salon to have its curls reset.
4. The policemen lined up with the dogs to face the rioters.

Summary

<table>
<thead>
<tr>
<th>The classical theory</th>
<th>Prototype theory</th>
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<tbody>
<tr>
<td>• Words are defined based on common features</td>
<td>• Words are defined based on a best exemplar</td>
</tr>
<tr>
<td>• Words (or categories) have clear-cut boundaries</td>
<td>• Words (or categories) have fuzzy boundaries</td>
</tr>
<tr>
<td>• All members of a category have equal status</td>
<td>• Some members are better examples of a certain category than others</td>
</tr>
<tr>
<td>• The meaning of words/categories is invariable</td>
<td>• The meaning of words/categories is culture and context dependent</td>
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</table>
**Color terms**

Brent Berlin and Paul Kay studied basic color expressions in more than 100 languages. A basic color term is defined by these features:

- It consists of a single word.
- It is not derived from a non-color term such as *orange*.
- It is not borrowed from another language such as *pink* (in German)
- It is not restricted in its reference such as English *blond*.

What Berlin and Kay found is that languages have between 2 and 12 basic color terms, which are arranged on an implicational scale:

1. White/black > red > green/yellow > blue > brown

Berlin and Kay also conducted some experimental studies on color terms. The results of their experimental studies can be summarized as follows:

- Speakers vary greatly when they are asked to mark the color region on a color chart.
- Speakers are surprisingly consistent when they are asked to indicate the most typical spot of a color on a color chart.

Stimulated by Berlin and Kay’s work, Eleanor Rosch conducted a number of experiments that were designed to answer the following questions: Are focal colors rooted in language or in pre-linguistic cognition. The results of her study can be summarized as follows:
• Focal color terms are perceptually more salient than non-focal colors.
• Focal colors are remembered more accurately.
• New names of focal colors are learned more easily than new names of non-focal colors.

The implication of Rosch’s work for the classical view

The groundbreaking work of Eleanor Rosch in the 1970s essentially killed the classical view, so that it is not now the theory of any actual researcher in this area ... That is a pretty far fall for a theory that had been the dominant one since Aristotle. [Murphy 2004]

Are categories in the physical sciences different?

Well, I’ll tell you something. You really don’t know what a metal is. And there’s a big group of people that don’t know what a metal is. Do you know what we call them? Metallurgists! … Here’s why metallurgists don’t know what metal is. We know that a metal is an element that has metallic properties. So we start to enumerate all these properties: electrical conductivity, thermal conductivity, ductility, malleability, strength, high density. Then you say, how many of these properties does an element have to have to classify as a metal? And do you know what? We can’t get the metallurgists to agree. Some say three properties; some say five properties, six properties. We really don’t know. So
we just proceed along presuming that we are all talking about the same thing. [Pond 1987; adopted from Murphy 2004: 18]

What is a prototype?

What determines the prototype? Three important features have been proposed:

1. Frequency (many studies)
2. Family resemblance (Rosch and Mervis 1975)
3. Purpose/function of a category (Barsalou 1985)

Ad hoc categories (Barsalou 1985):

- Good birthday presents
- Things to eat on a diet
- Things to take from one’s house when it is on fire

How is a prototype represented?

One possibility is that the prototype is represented by a concrete instance of the category. But this view has serious problems. Another possibility is that the prototype is based on a summary representation. A summary representation is a structured feature list that includes all relevant features including their relative importance.

The exemplar view
In the exemplar model, there is no abstract summary representation of a category. Instead, categories are defined by all tokens of a particular entity that somebody has encountered. Every time a person encounters a particular entity it leaves a trace in memory. Over time, these traces reinforce each other and constitute a token-cluster that functions as a mental reference point for the categorization of new items.

Prototype theory and the exemplar model focus on different aspects of categorization. The exemplar model emphasize that categories are grounded in our experience and that we store individual encounters with concrete tokens. The prototype model emphasizes that we construct summary representations of from concrete experience.

The human mind includes both individual tokens and abstract concepts; both are important for categorization. From this perspective, prototype theory and the exemplar model complement each other.

**Similarity**

Both prototype theory and exemplar theory emphasize the importance of similarity for categorization. Two entities can be more or less similar to each other depending on the features they share. The problem is that there are often many dimensions along which entities can be compared. Both psychologist and computer scientists have developed similarity calculation to determine and measure similarity, but there is still much disagreement and confusion. We know that similarity determines the relationship between categories, but we don’t know exactly how it works. (Tversky 1977)
Taxonomies

Categories are organized in hierarchies. These hierarchies are commonly based on the principle of class inclusion; i.e. categories at a higher level include all categories at a lower level. Category hierarchies are commonly represented in taxonomies. In the 19s century, scientist proposed complex taxonomies for large knowledge domains or even for ‘world knowledge’.

Mark Roger (adopted from Unger and Schmid 1996)
One problem of classical taxonomies is that they are based on the assumption that category membership is strictly transitive: If all As are Bs, and all Bs are Cs, then all As must be Cs.

```
    furniture
     
    chair
     
  kitchen chair
```

A kitchen chair is a type of chair. A chair is furniture. Thus a kitchen chair is furniture.

```
    furniture
     
    chair
     
  car seat
```

A car seat is a type of chair. A chair is furniture. But a car seat is not furniture.

On the classical view, this kind of intransitivity is impossible. Class inclusion is absolute so that every superordinate category subsumes all categories at a lower level. Obviously, in real life hierarchical relationships are not strictly transitive. For prototype theory, this is not a problem because in prototype theory categories have fuzzy boundaries so that there cannot be strict class inclusion.
The generic level includes far more members than all other levels. The large number of generic categories reflects the linguistic and cultural significance of categories at this level. Basic level categories are distinguished from other categories by the following features:

- Basic level categories carry more distinctive features than categories at higher or lower levels.
- Basic level categories are associated with specific shapes.
- Basic level categories are associated with specific types of motor actions.
<table>
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<tr>
<th>Levels of categorization</th>
<th>Gestalt</th>
<th>Attribute</th>
<th>Function</th>
<th>Linguistic form</th>
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<tr>
<td>Basic level categories</td>
<td>Common gestalt</td>
<td>Large number of attributes</td>
<td>‘Natural’ access to the world</td>
<td>Monomorphemic</td>
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<tr>
<td>Superordinate categories</td>
<td>No common gestalt</td>
<td>Few attributes</td>
<td>Highlighting + collecting</td>
<td>Often morphologically complex</td>
</tr>
<tr>
<td>Subordinate categories</td>
<td>Almost identical gestalts</td>
<td>Large number of attributes</td>
<td>Specifying</td>
<td>Compounds, noun-adjective phrases</td>
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