Categorization

Holger Diessel
University of Jena

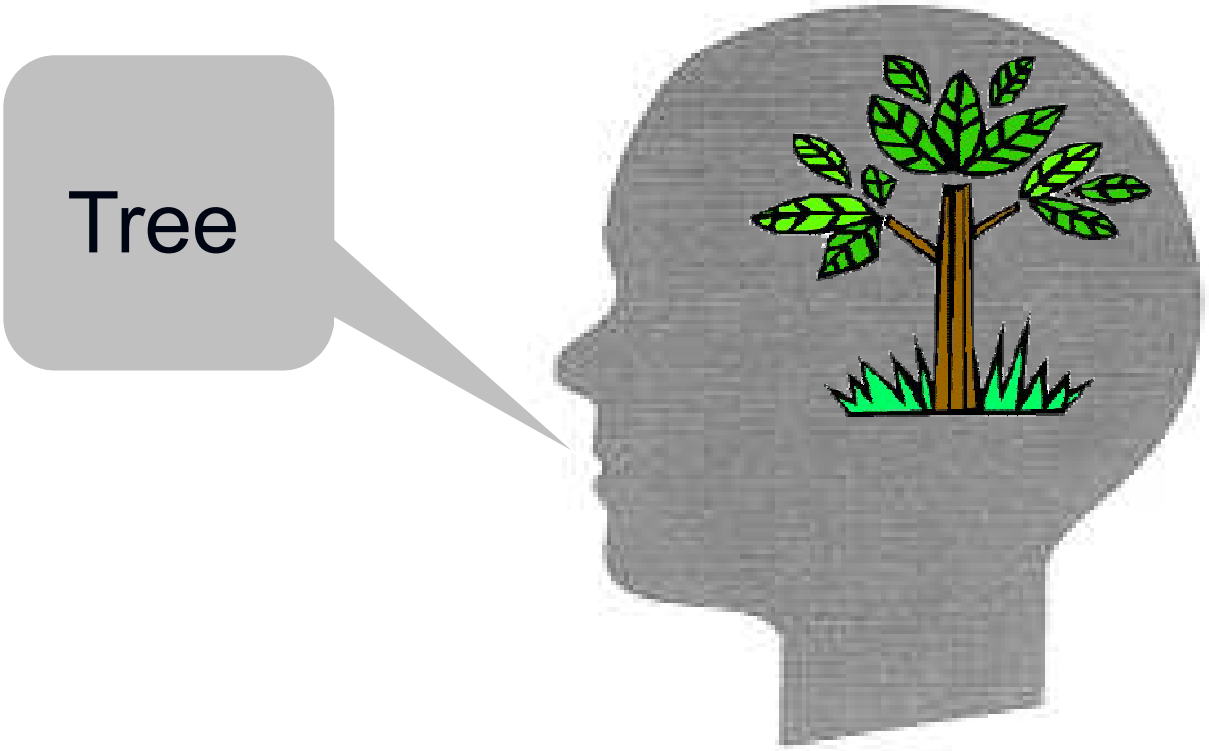
holger.diessel@uni-jena.de
http://www.holger-diessel.de/

Categorization

Categories are the basic elements of human cognition; they “are the glue of our mental world” (Murphy 2002).

Categorization

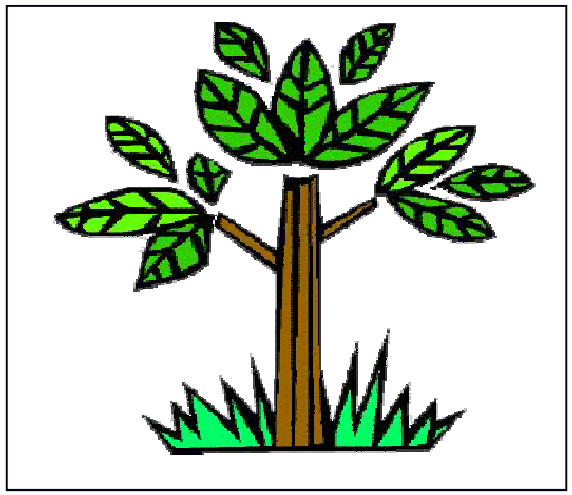
Categorization

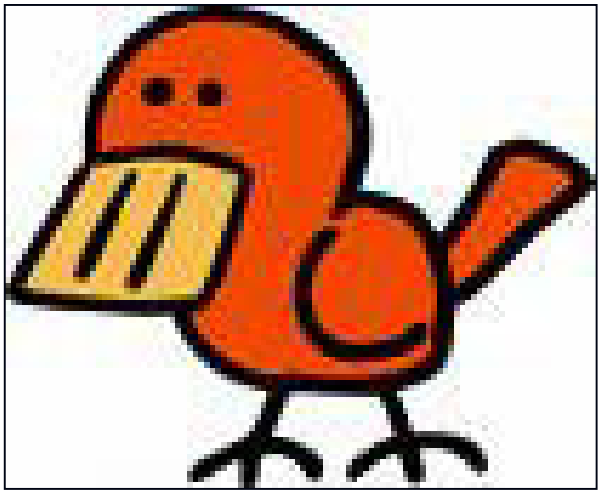


Categorization

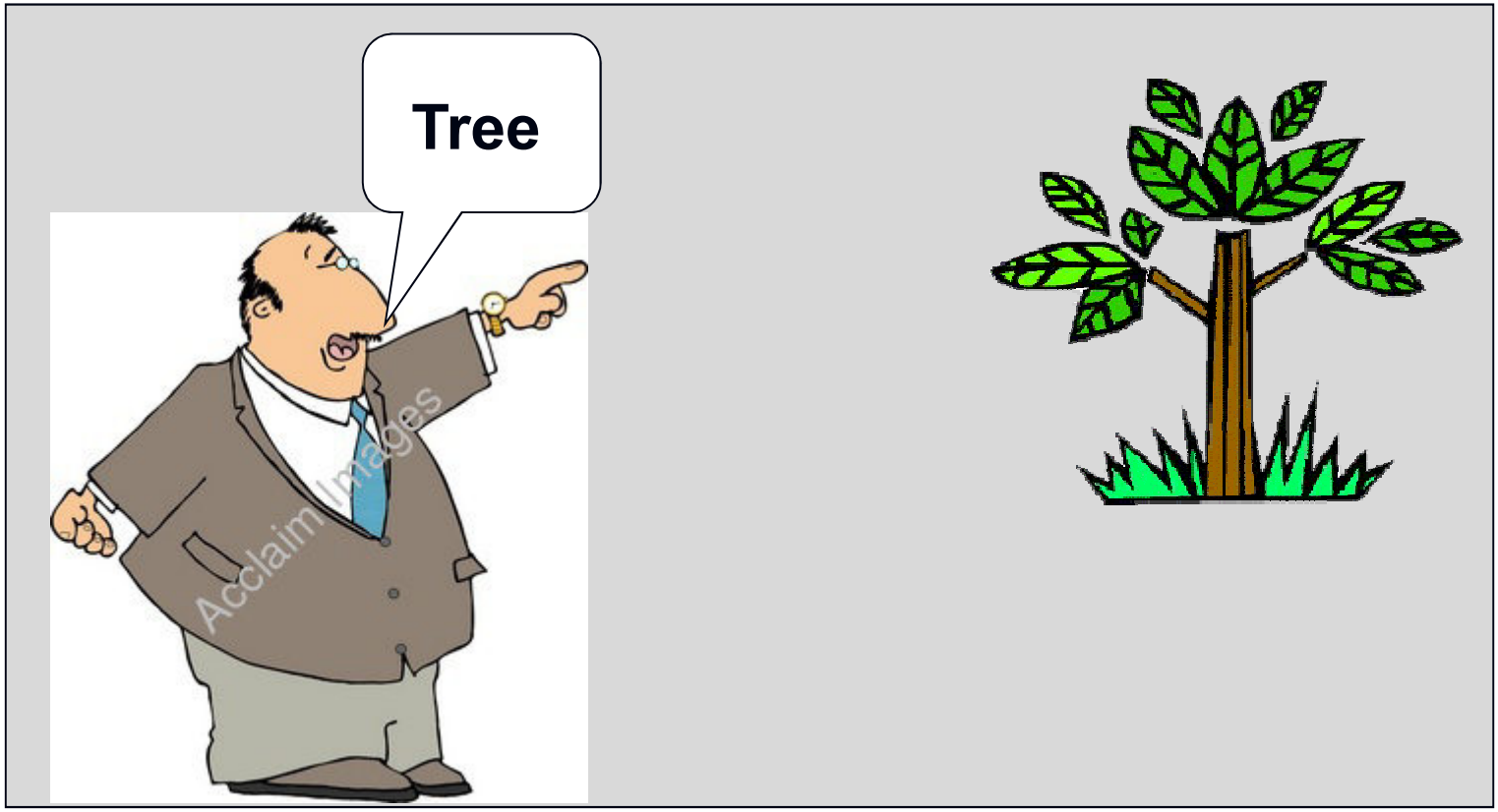
What’s in a word?

Categorization





Categorization



Categorization

- Love, hate, war
- Running, reading, thinking
- Warm, cold
- Black, white

Categorization

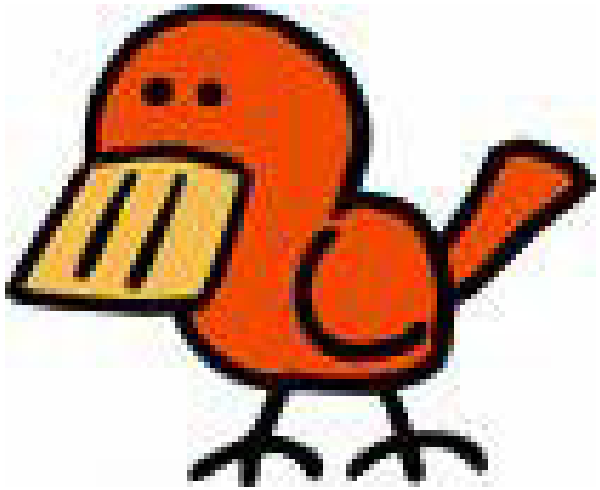
How are categories mentally organized?

Categorization

- Classical view
- Prototype view
- Exemplar view

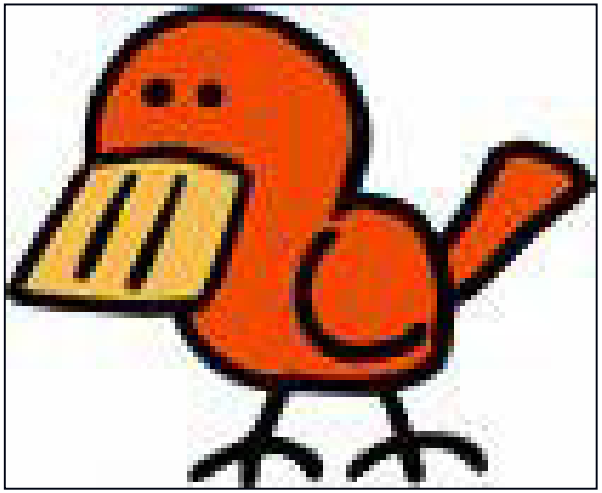
Categorization

What is a bird?



The classical view

- A bird is an animal.
- It has feathers.
- It has two wings.
- It has a beak.
- It lays eggs.
- It can usually fly.

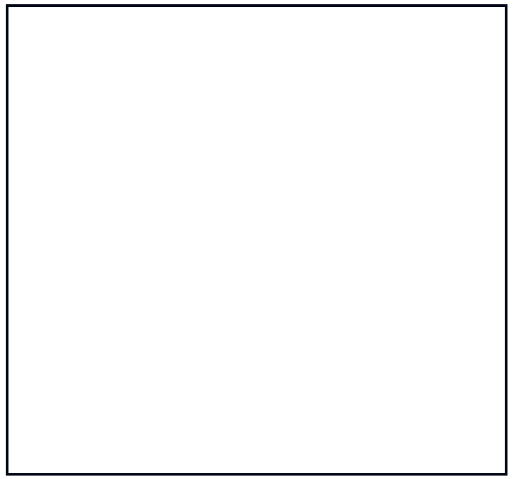


Categorization

Categories are defined by necessary and sufficient criteria.

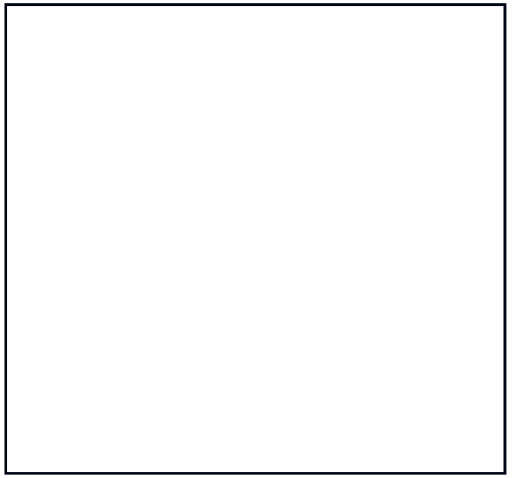
Categorization

What is a square?



Categorization

- A square is a closed, flat figure.
- It has four sides.
- All sides are equal in length.
- All interior angles are equal.



The classical view

- Necessary and sufficient criteria.
- Clear-cut boundaries between neighboring categories.
- All category members have equal status.

Problems

The classical view

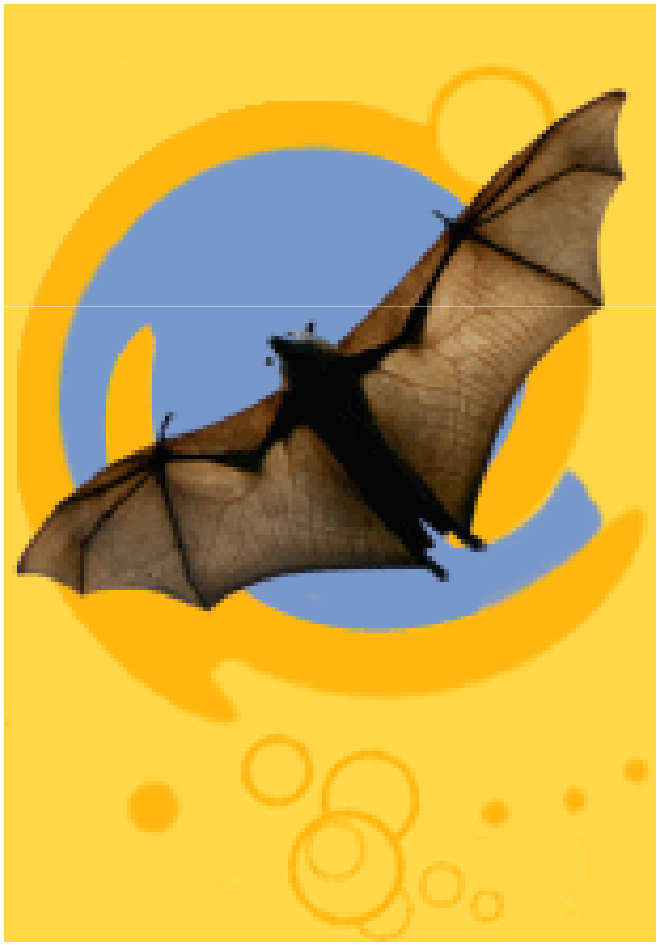
Which features should be included on the feature list?

The classical view

Can all birds fly?

The classical view

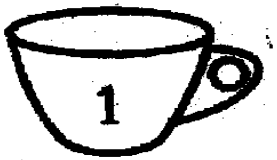
Is flying an exclusive feature of birds?



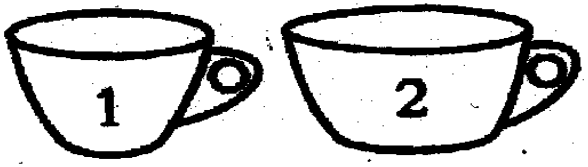
The classical view

Some categories have fuzzy boundaries.

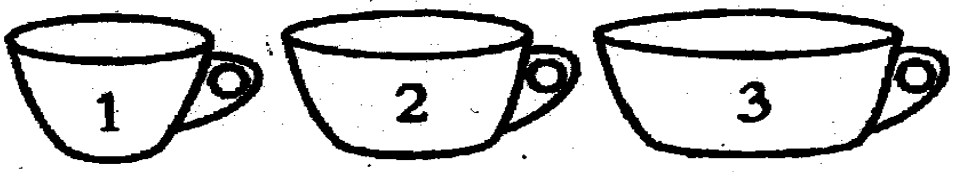
Labov 1975



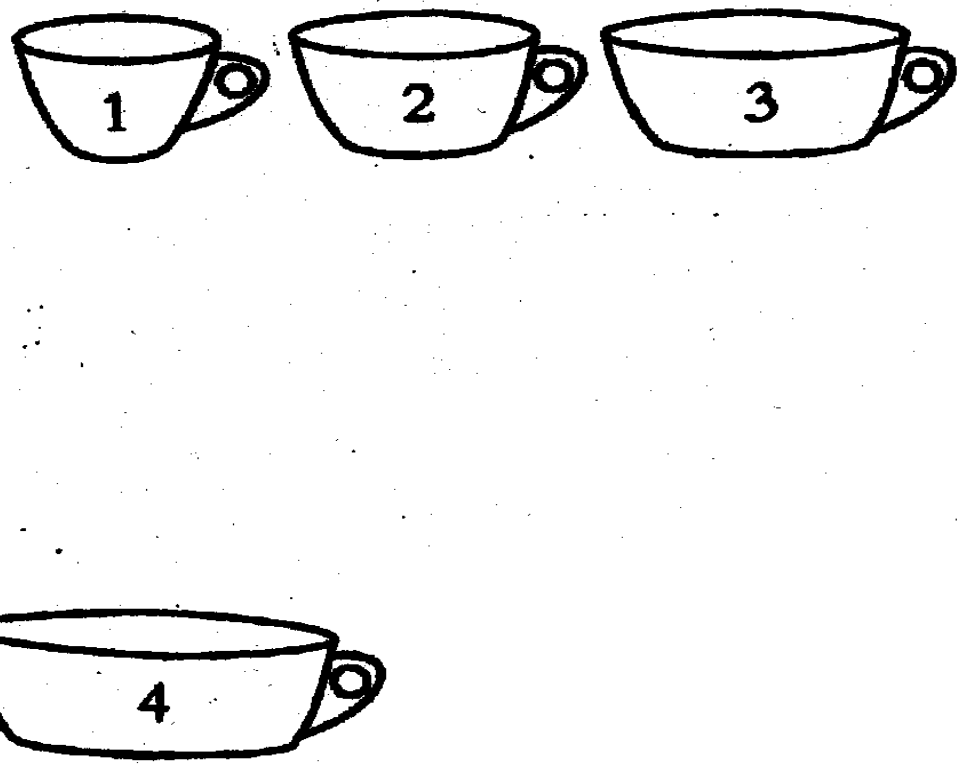
Labov 1975



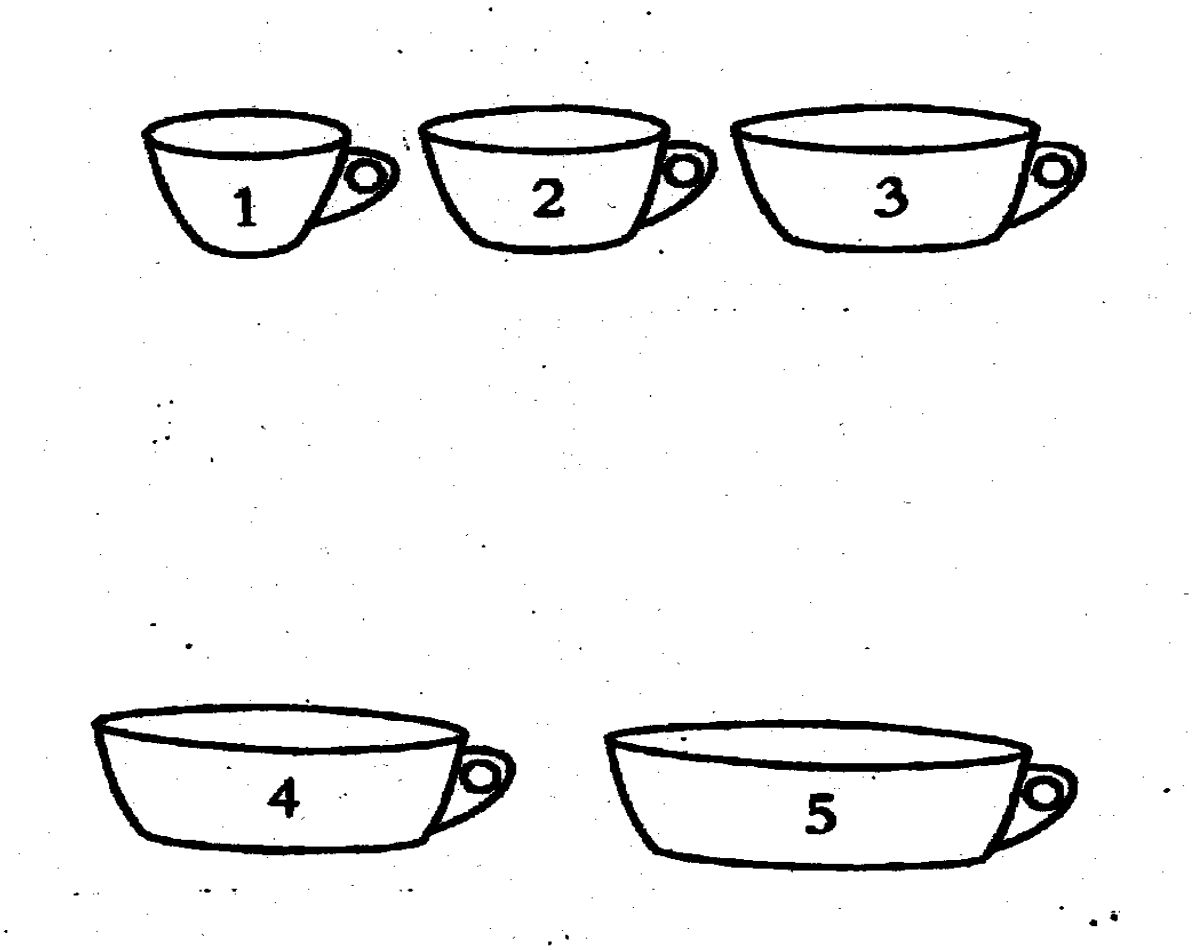
Labov 1975



Labov 1975



Labov 1975



Labov 1975

The classical view

Some category members do not have a single feature in common.

Wittgenstein 1956

- Board games
- Card games
- Ball games
- Olympic games
- War games
- Computer games

Games

Games are played for fun and amusement.

Games

Games

Games involve opposing teams.

Games

Games

Games have winners and loosers.

Games

Family resemblance

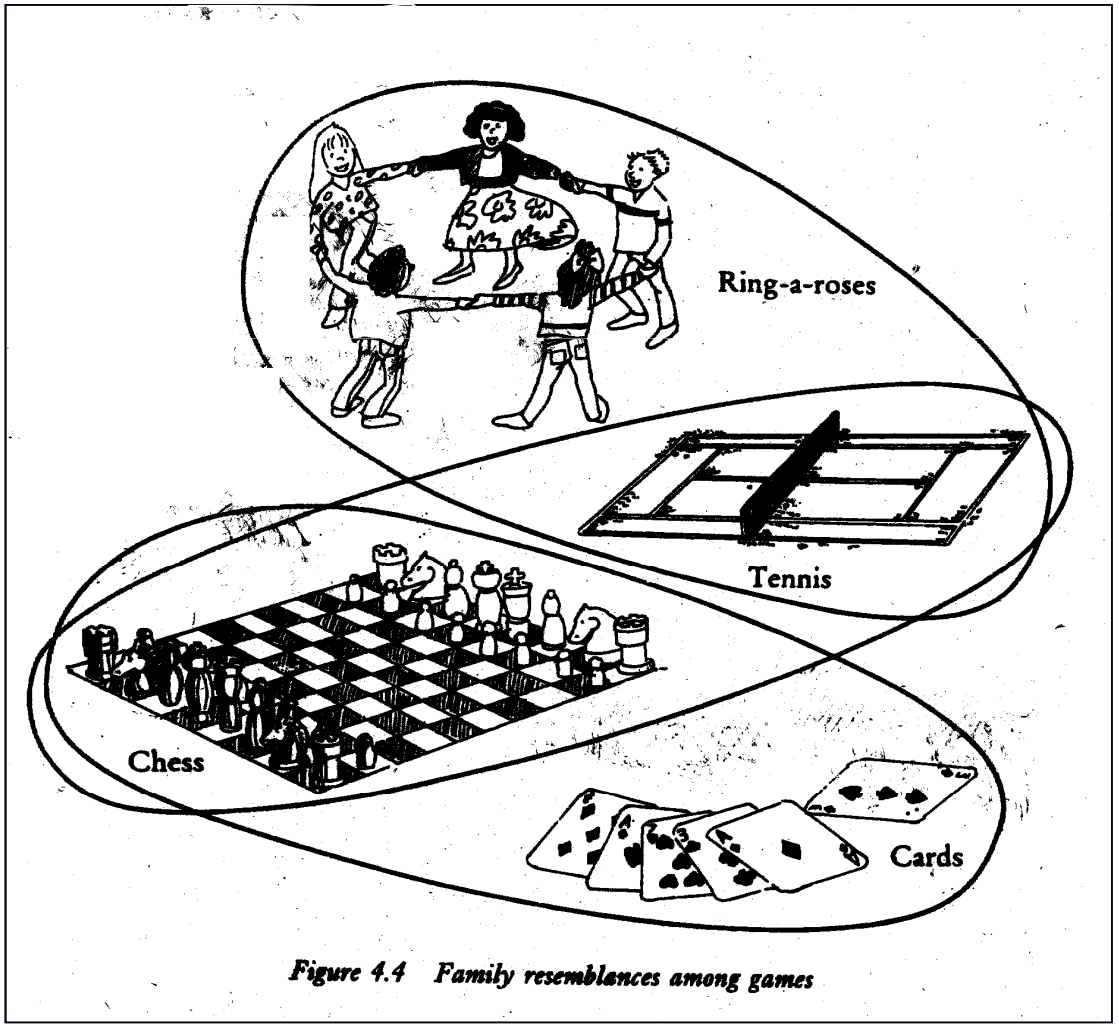


Figure 4.4 Family resemblances among games

Alternative views

Eleanor Rosch: The prototype view

The prototype view

Is it a vehicle?

(i) train

(ii) bike

(iii) car

(iv) shop

(v) truck

(vi) plane

The prototype view

Is it furniture?

(i) table

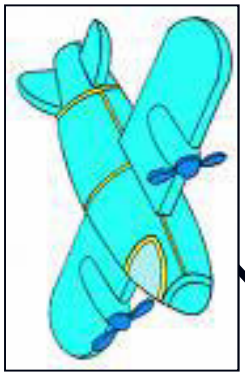
(ii) telephone

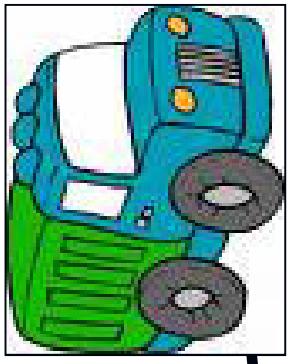
(iii) piano

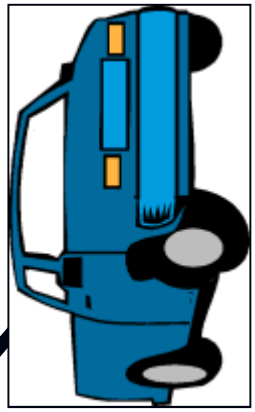
(iv) chair

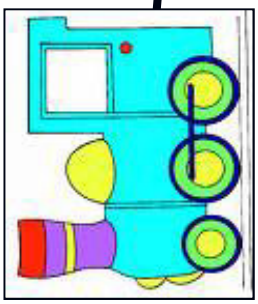
(v) picture

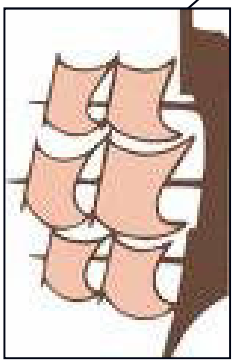
(vi) lamp

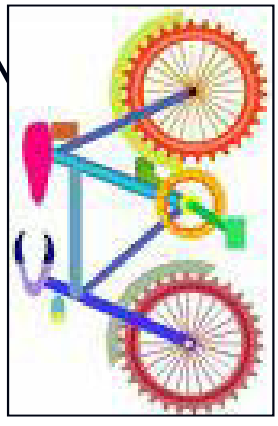












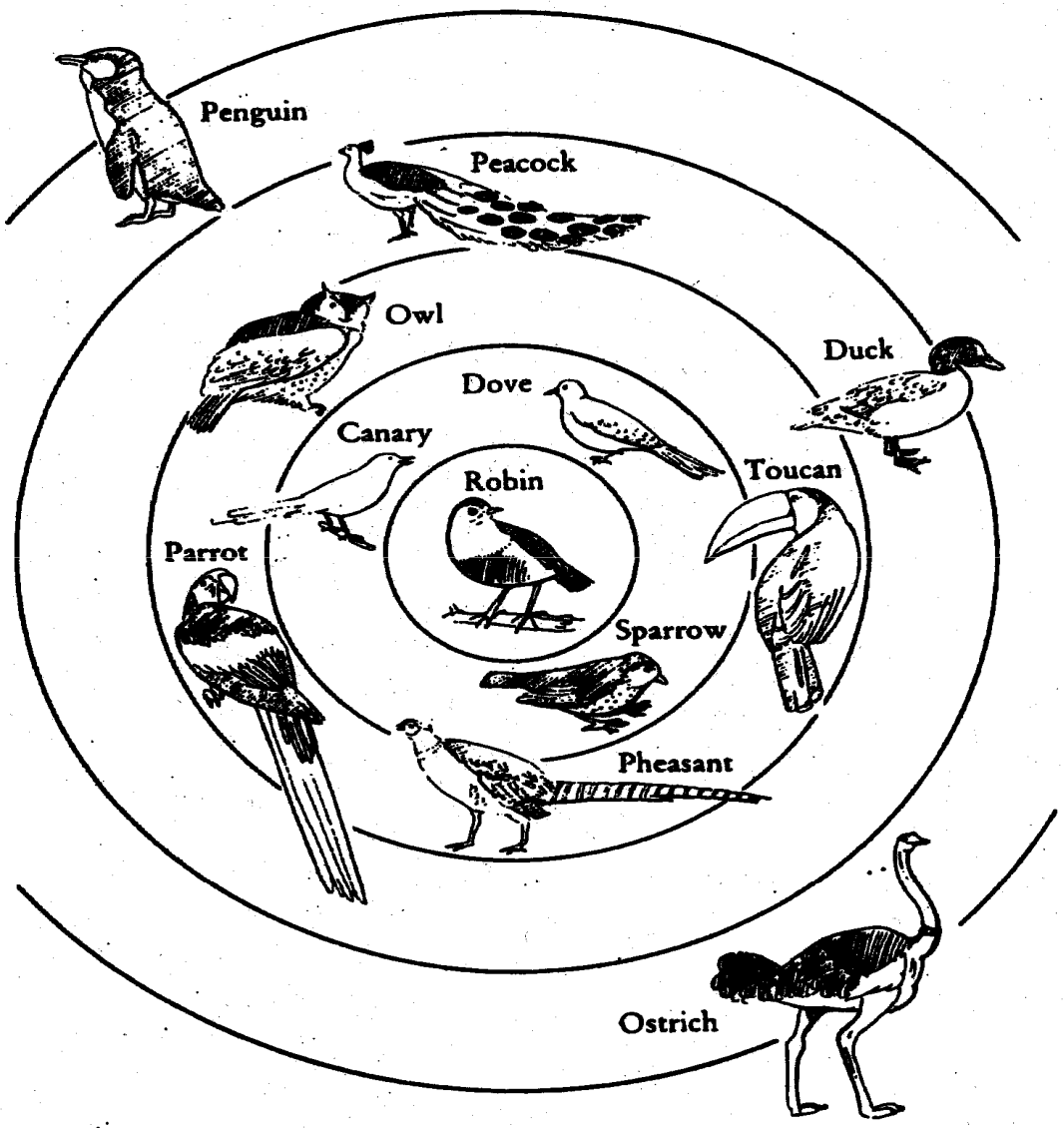
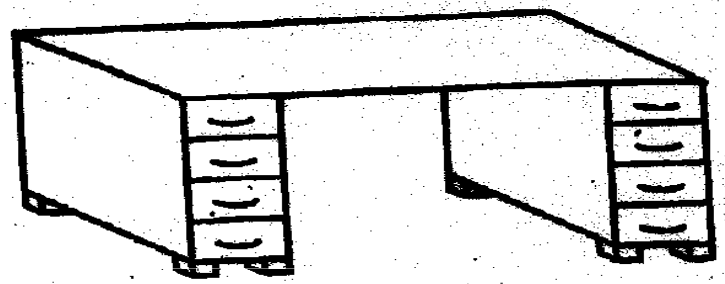
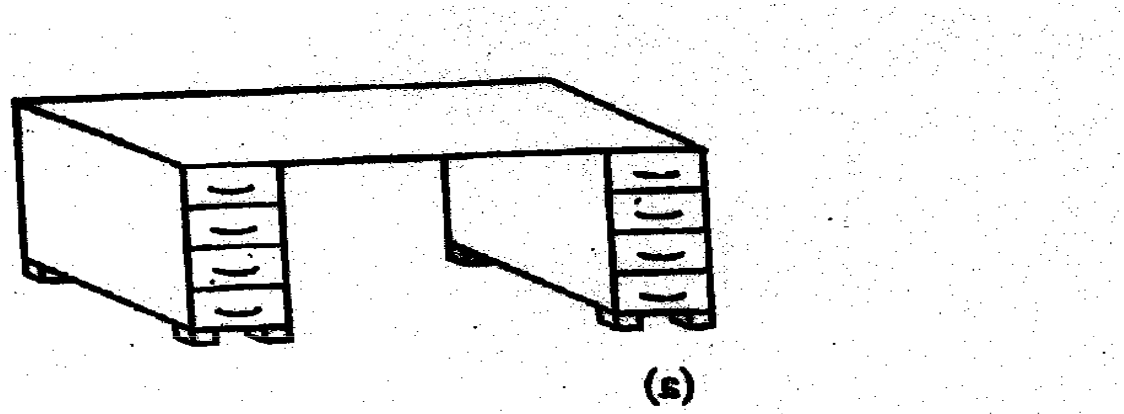


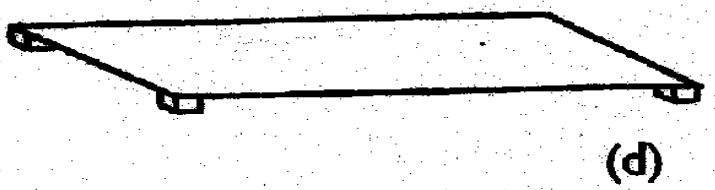
Figure 5.1 Birdiness rankings

Culture specific categories



Culture specific categories





Culture specific categories

Culture specific categories

Context dependency

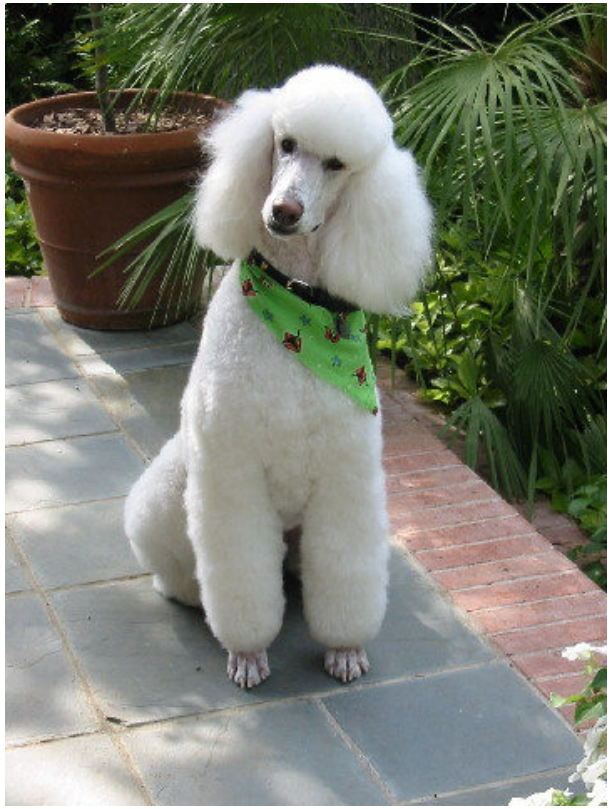
The hunter took his gun, left the lodge and called his dog.

Context dependency

Right from the start of the race the dog began chasing the rabbit.

Context dependency

She took her dog to the salon to have its curls reset.



Context dependency

The policemen lined up with the dogs to face the rioters.

Context dependency

The policemen lined up with the dogs to face the rioters.

Summary

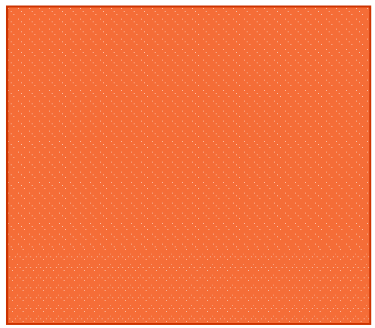
The classical theory	Prototype theory
• Words are defined based on common features	• Words are defined based on a best exemplar
• Words (or categories) have clear-cut boundaries	• Words (or categories) have fuzzy boundaries
• All members of a category have equal status	• Some members are better examples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

Fuzziness vs. vagueness

Color categories

Yellow or brown?

Yellow or green?



Red or brown?

Color categories

Berlin and Kay 1967: Basic color terms

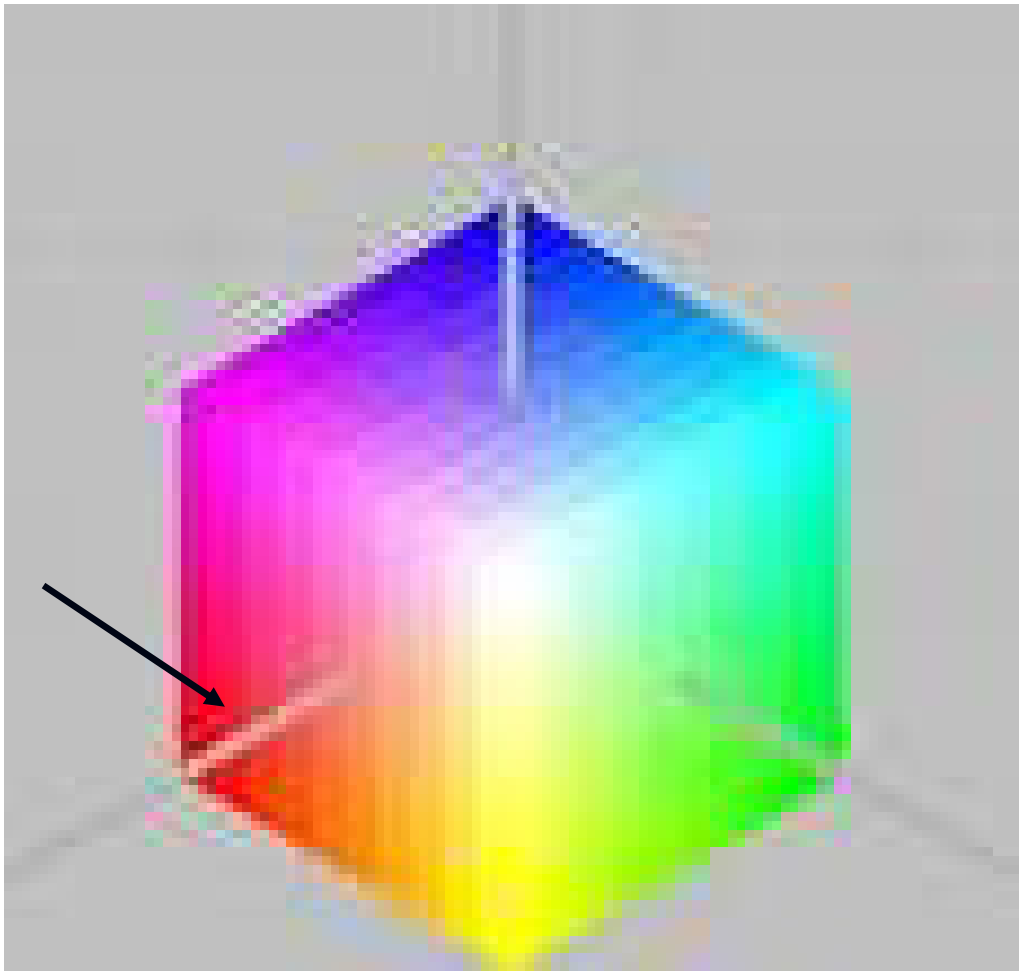
- They consist of a single word.
- They are not derived from a non-color term such as *orange*.
- They are not borrowed from another language such as *pink* (in German).
- They are not restricted in their reference such as English *blond.*

Color categories

Berlin and Kay 1967: Basic color terms

white/black > red > green/yellow > blue > brown

Color categories



Berlin and Kay

1967

Color categories

Color categorization is based on focal colors.

Why are focal colors so important?

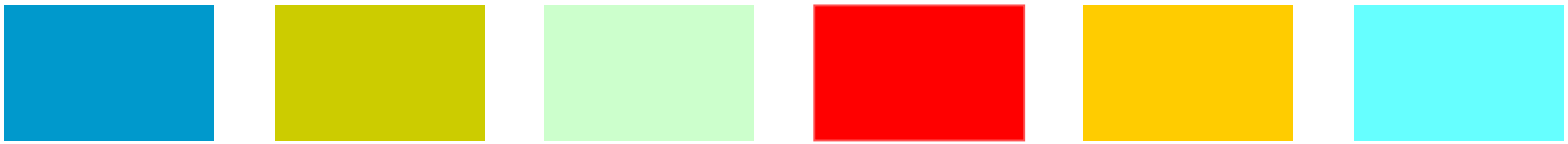
Two hypotheses:

(1) Focal colors are rooted in language

(2) Focal colors are rooted in pre-linguistic knowledge

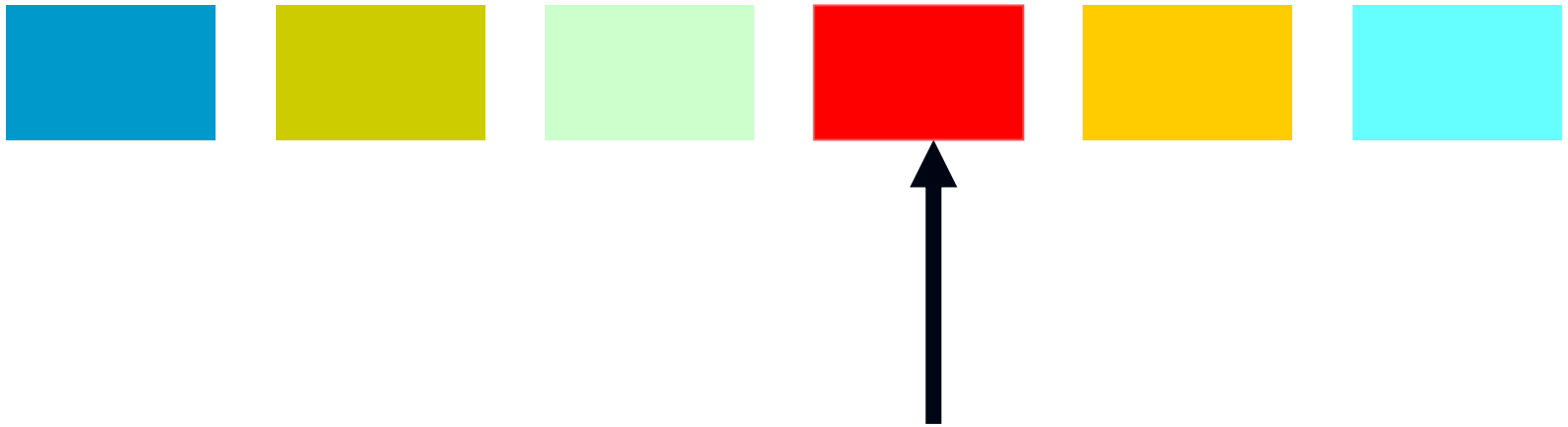
Color categories

Color categories



Show me any color you like.

Color categories



Color categories

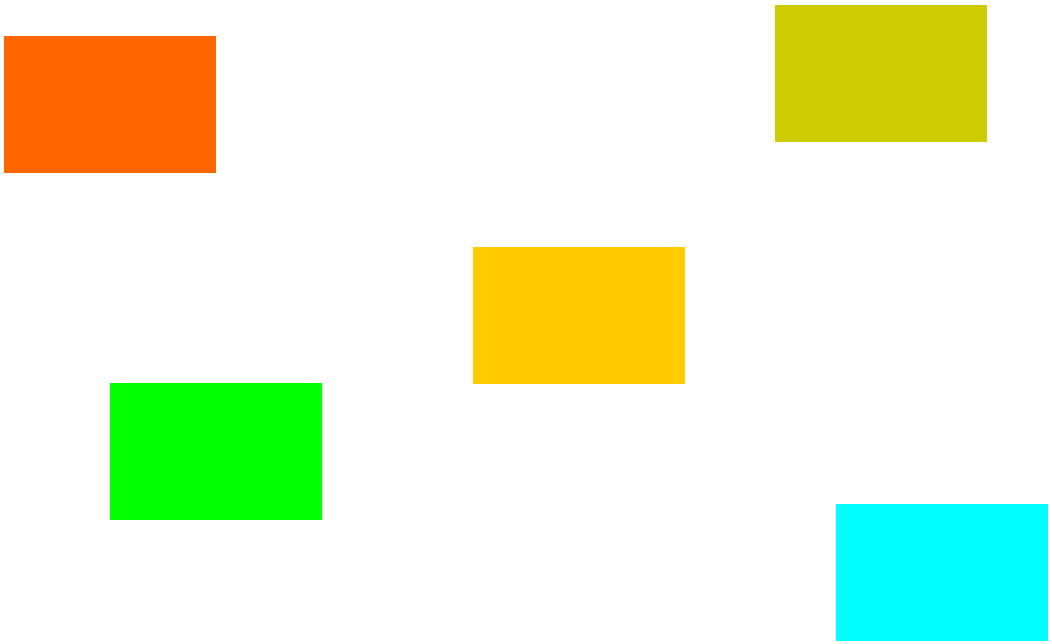
Color categories

Color categories

Color categories

Color categories

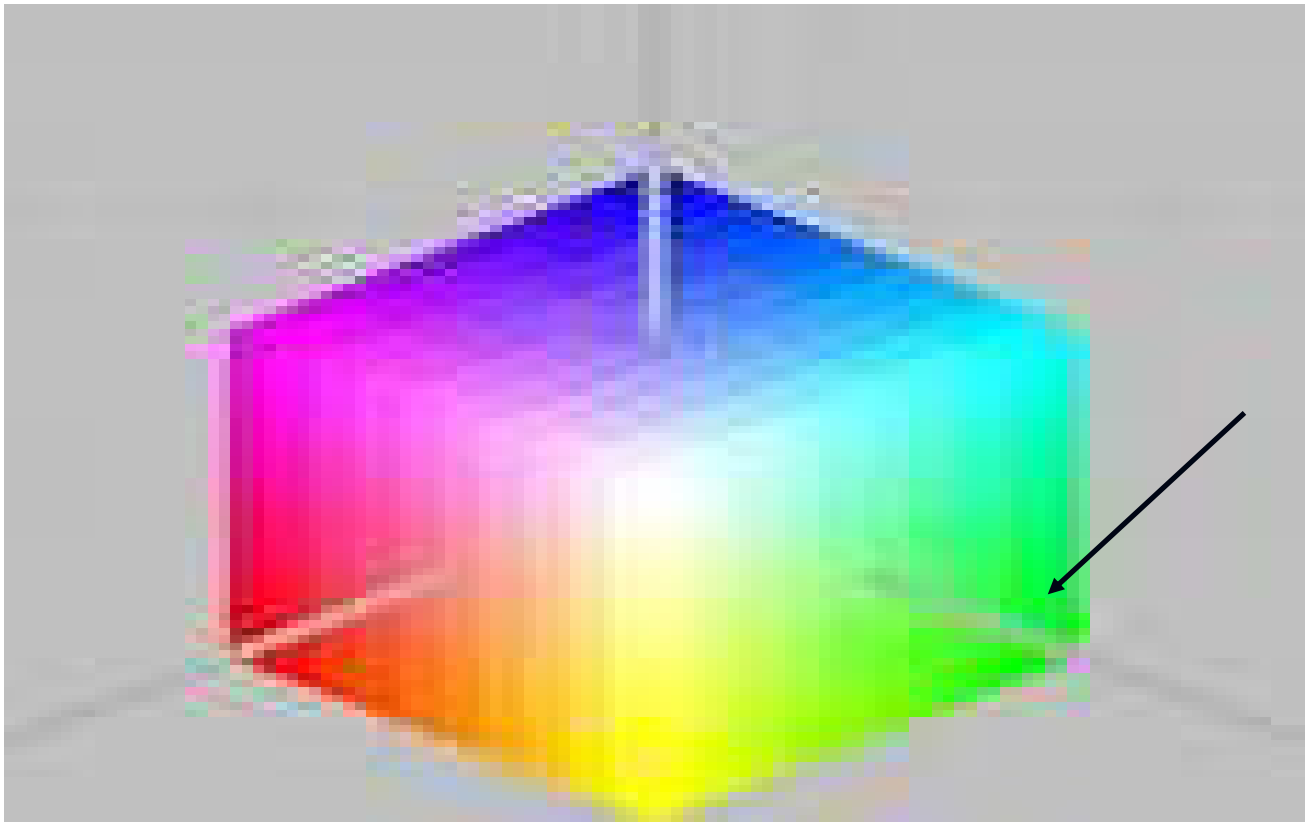
Color categories



Color categories

Color categories

Show me the colors you have seen.



Color categories

bek

sik

tog

pog

dub

kat

Rosch 1975.

Color categories

sik

pog

bek

kat

tog

dub

Color categories

dub

pog

kat

tog

bek

sik

What’s the name of the color?

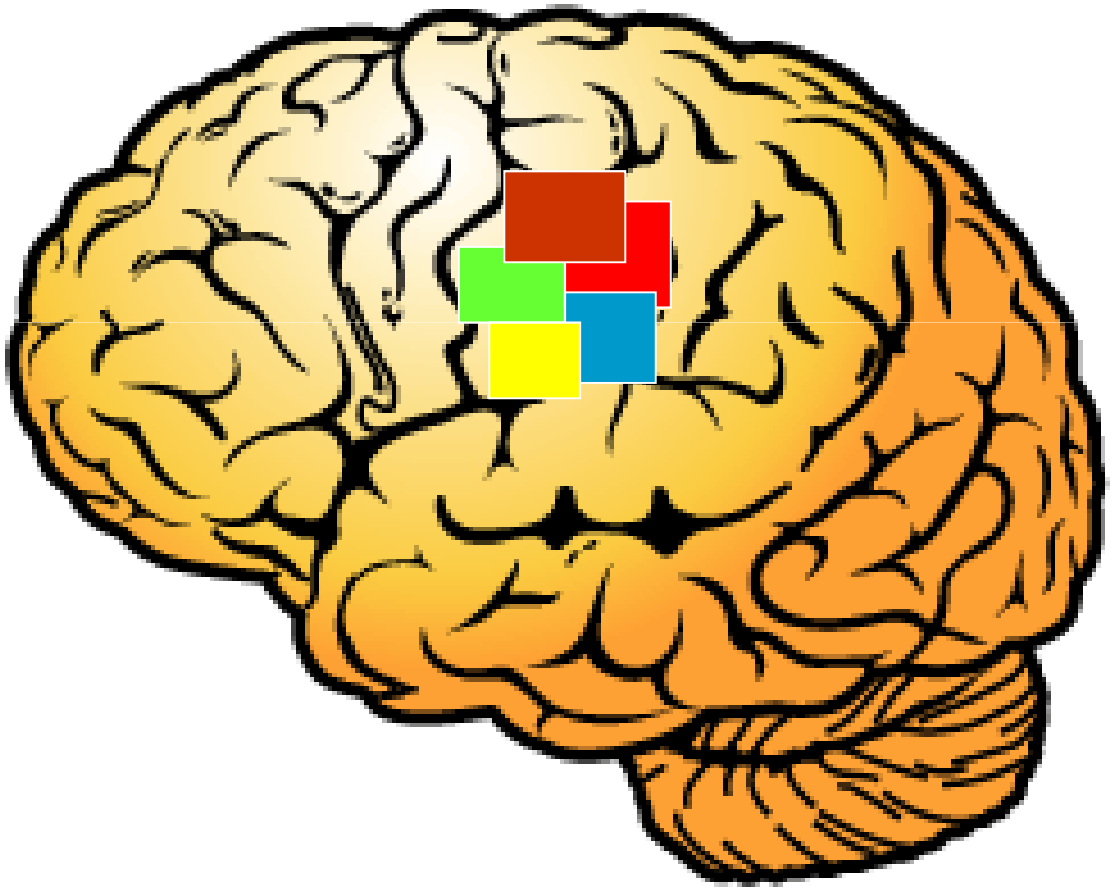
Color categories

- Focal color terms are perceptually more salient than non-focal colors.
- Focal colors are remembered more accurately in short and long term memory.
- New names of focal colors are learned more easily than new names of non-focal colors.

Color categories

How do we account for these findings?

Color categories



Color categories

Wierzbicka
1990

Debates about categories

Theoretical issues

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]

Theoretical issues

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.

Theoretical issues

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]

Theoretical issues

Human beings have the ability to think on the basis of classical categories.

What is a prototype?

Why is a robin the prototype of a bird?

Why is a German shepherd a more prototypical member of the category dog than a bulldog or a poodle?

How is the prototype represented in the mind?

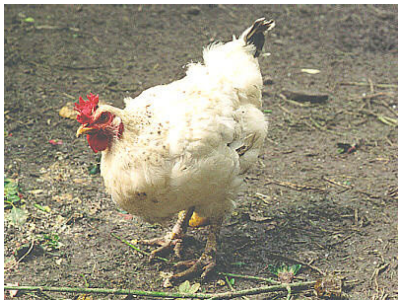
Where do prototypes come from?

Prototype theory or prototype effects?

What determines the prototype?

Frequency

Frequency



Rosch & Mervis 1975: family resemblance

Goal/purpose

ad hoc categories

birthday presents

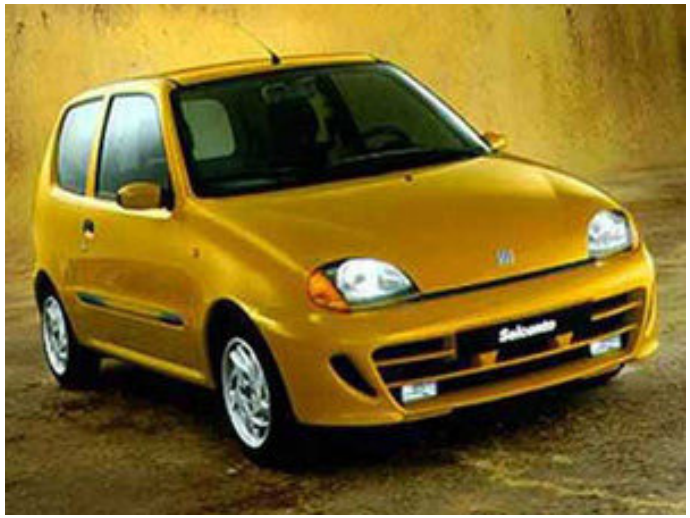
things to eat on a diet

things to take from one’s home when it’s on fire

Prototypicality

- Frequency
- Family resemblance (similarity)
- Goal / purpose

How is the prototype represented in the mind?



The prototype is a concrete category member.

Summary representation: The prototype is an abstract schema that consists of weighted and related features.

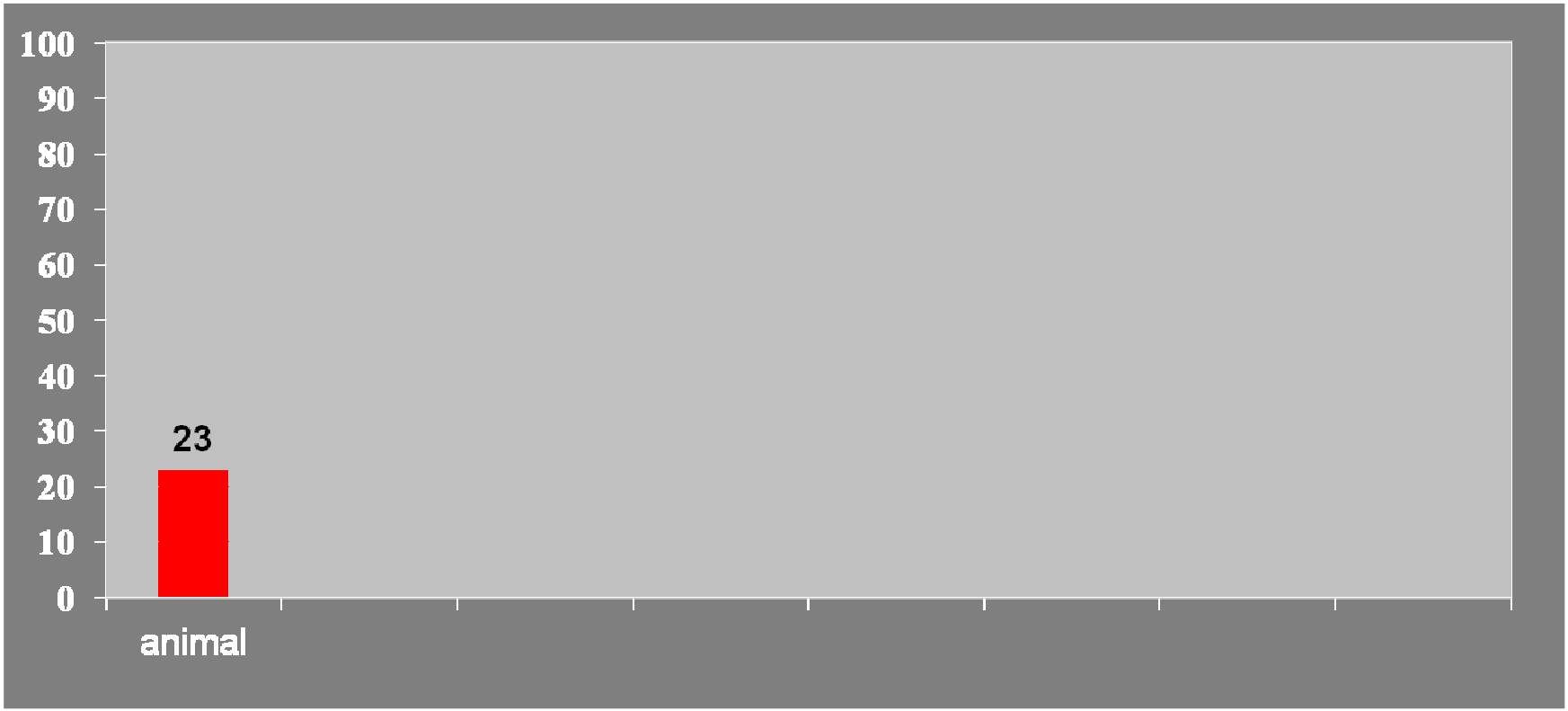
Structured feature list

- Features are not necessary
- Features are weighted
- Features are related
- Features are context-dependent?

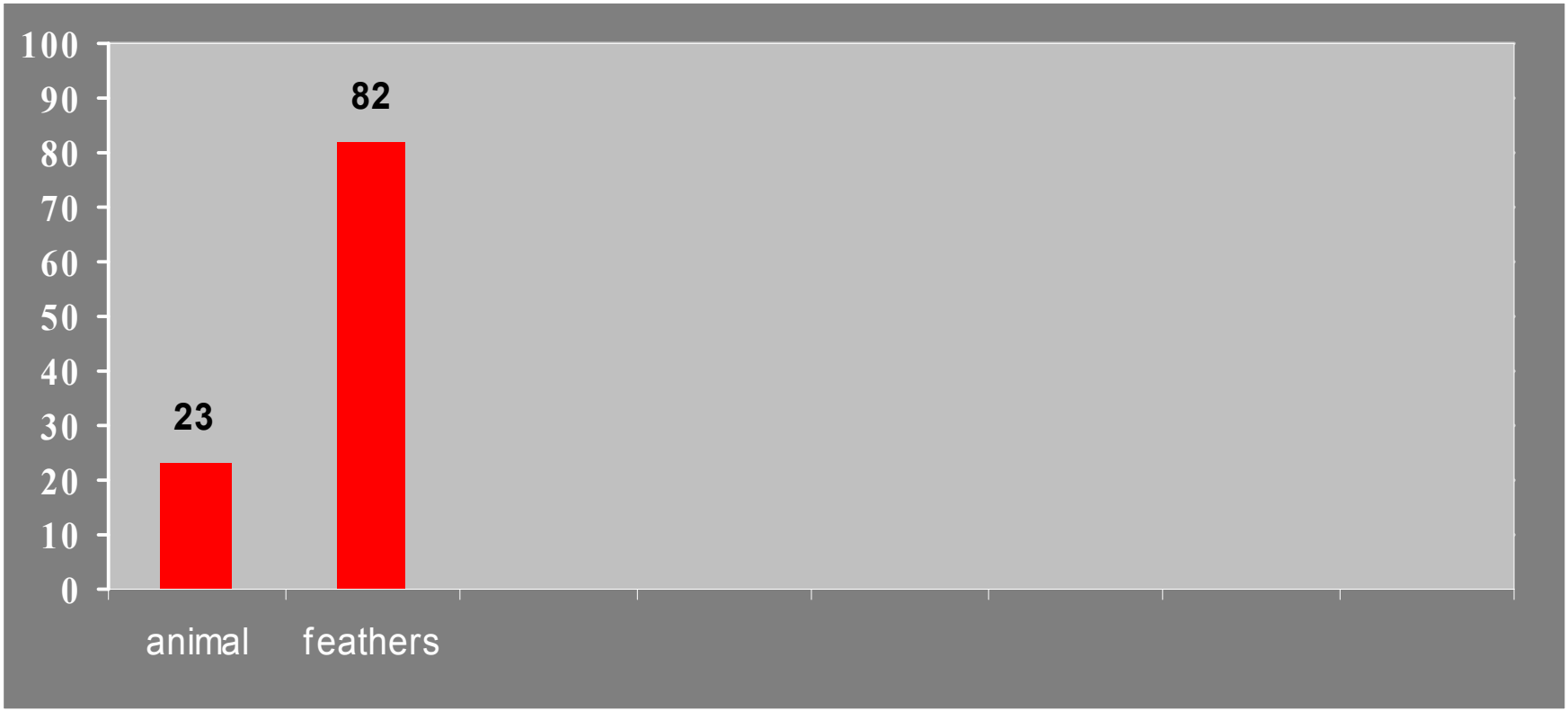
Structured feature list

What is a bird?

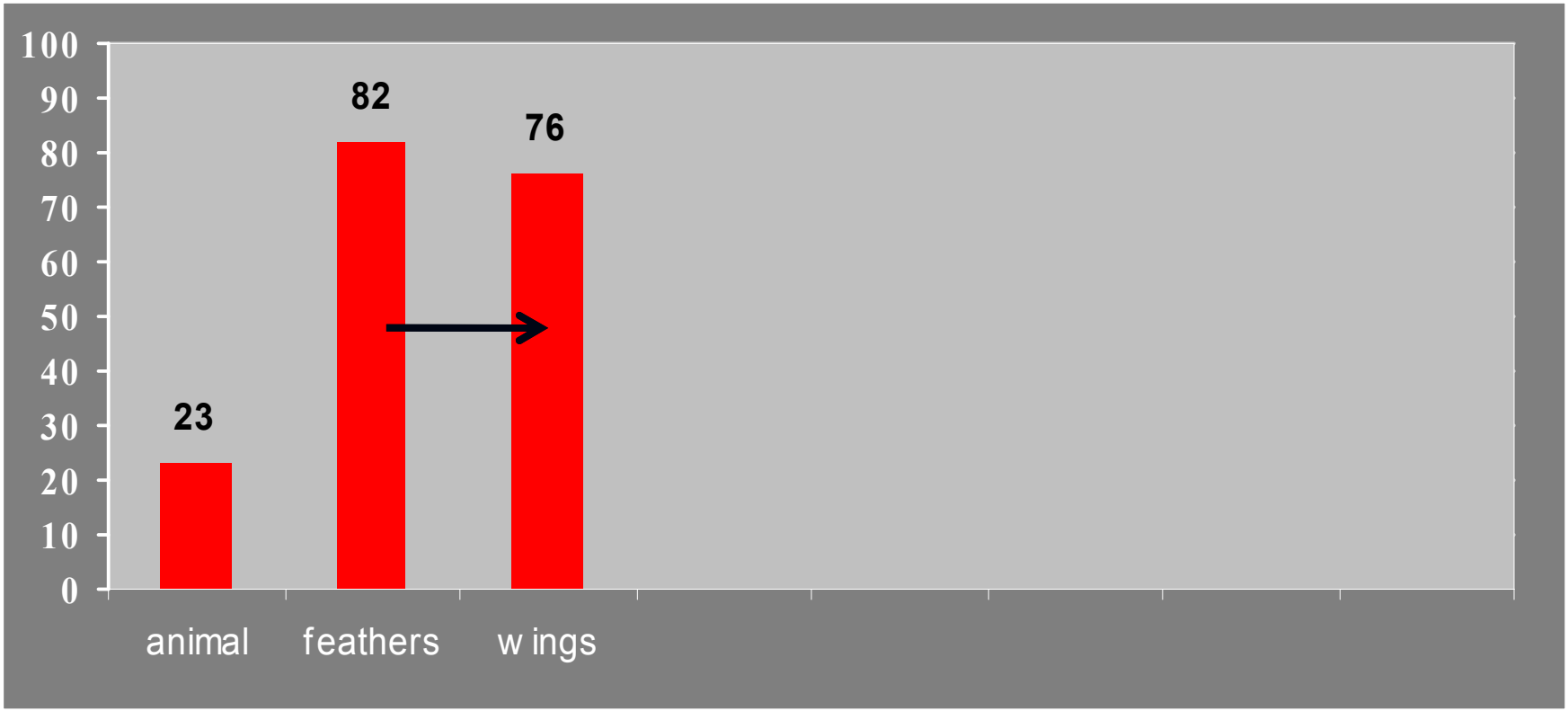
Structured feature list



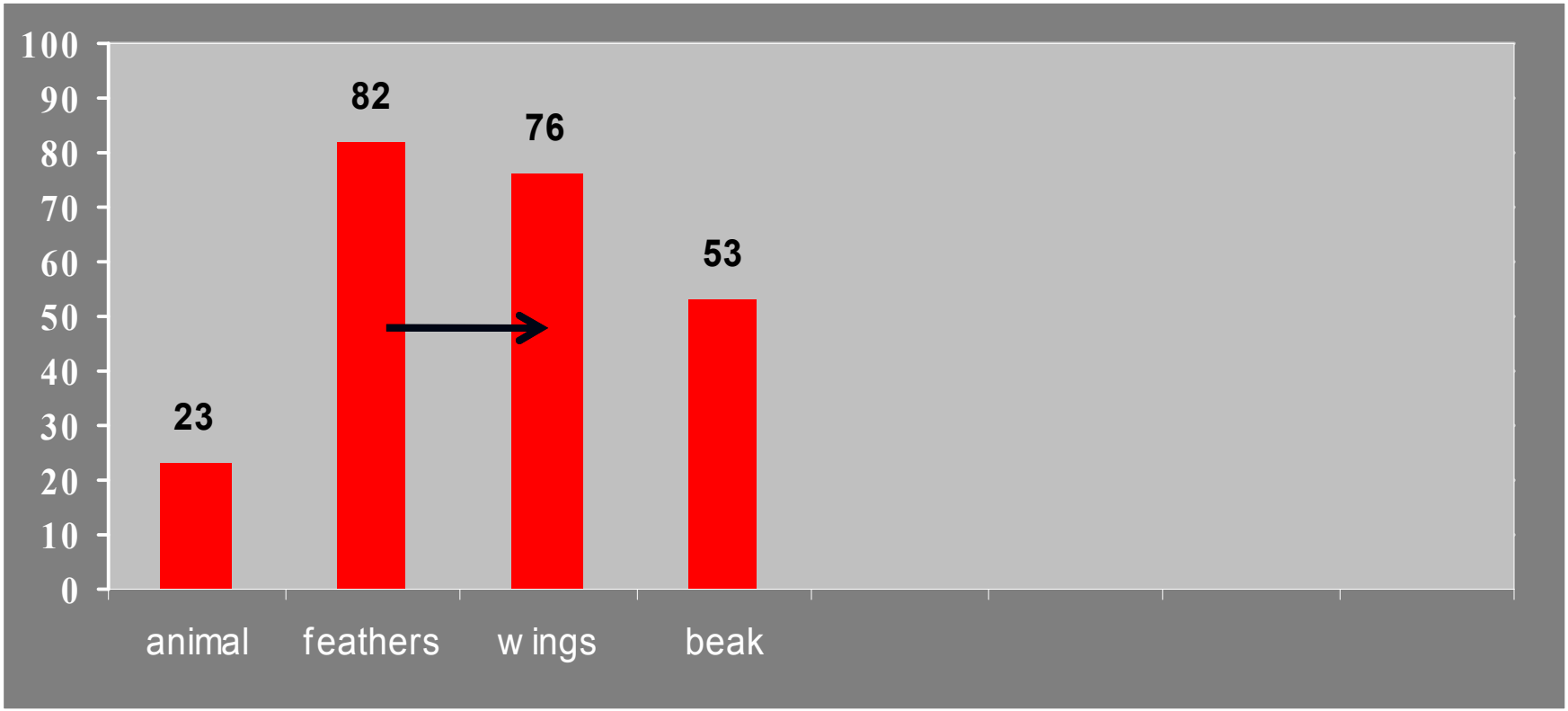
Structured feature list



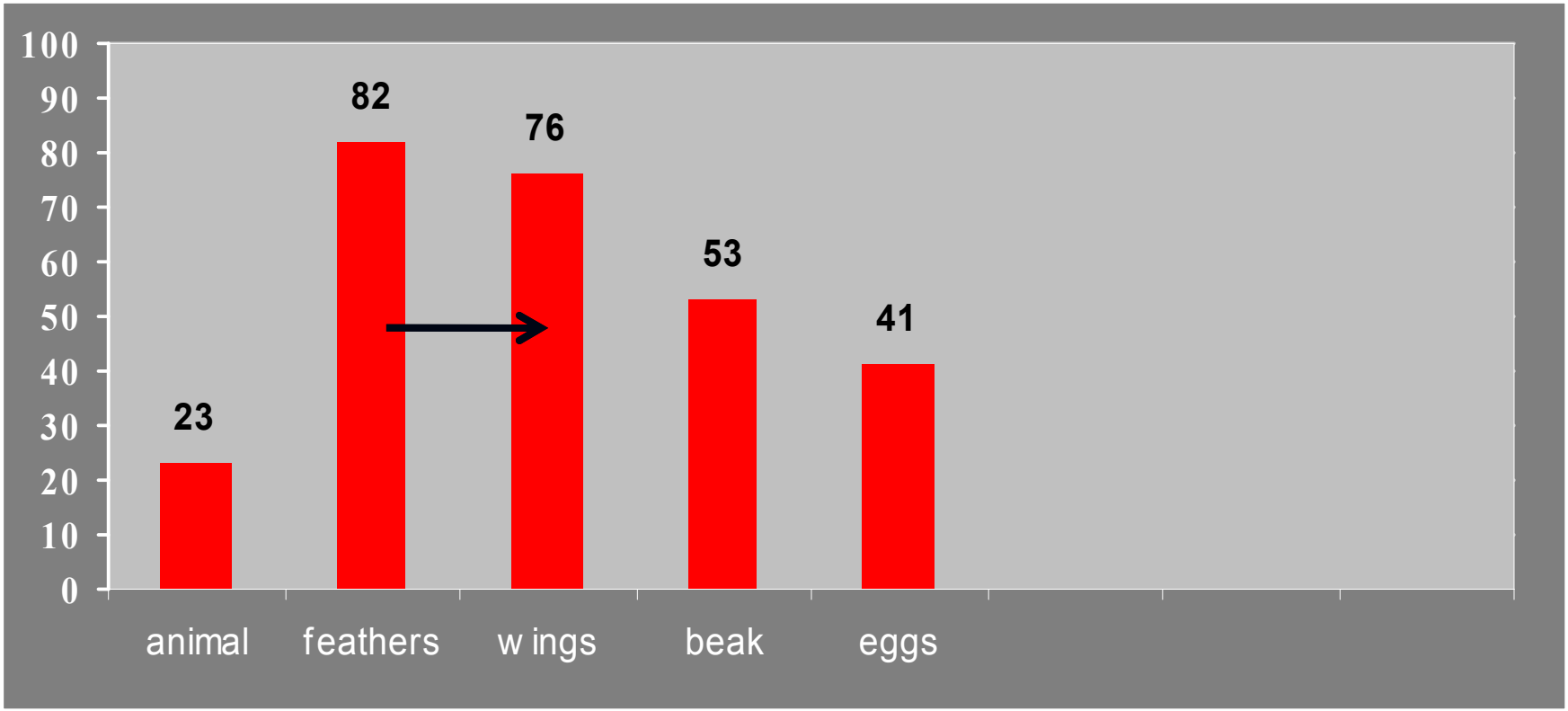
Structured feature list



Structured feature list



Structured feature list



Structured feature list

Structured feature list

Structured feature list

Prototype theory

- There is no unified prototype theory
- The term prototype is used in different ways
- There is an alternative to prototype theory: Exemplar theory

Exemplar view

Exemplar theory

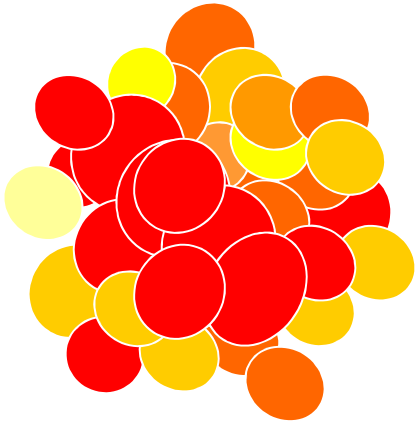
There is no abstract summary representation.

Categories are defined by the tokens a person encounters.

Token clusters serve as reference points (attractors).

Exemplar theory

Exemplar theory



Exemplar theory

attractor

Exemplar theory

attractor

Exemplar theory

attractor

Exemplar theory

Prototype theory – exemplar theory:

Alternatives or complements?

Prototype theory – Exemplar theory

Exemplar theory emphasizes:

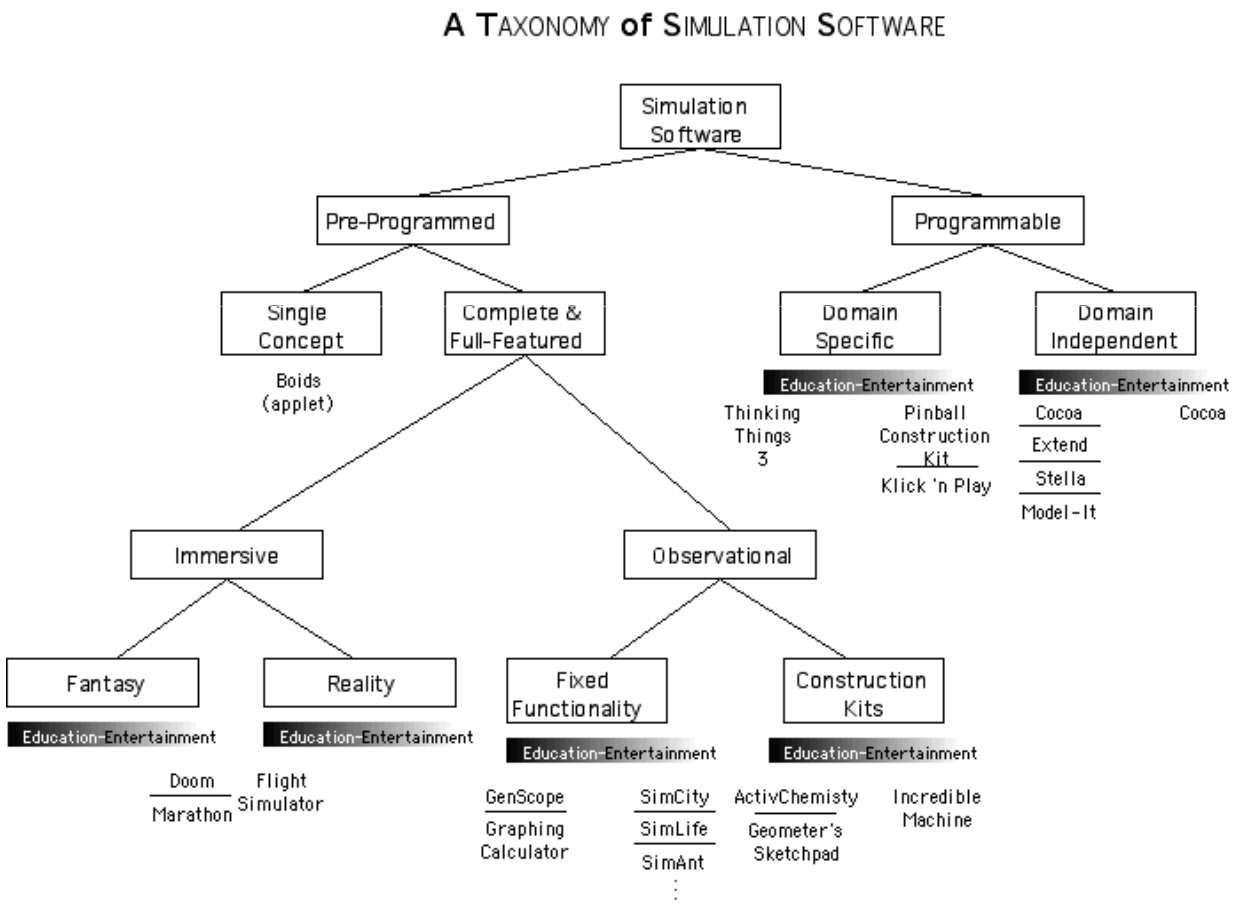
- Categories are grounded in experience.
- Human beings store concrete tokens.

Prototype theory emphasizes:

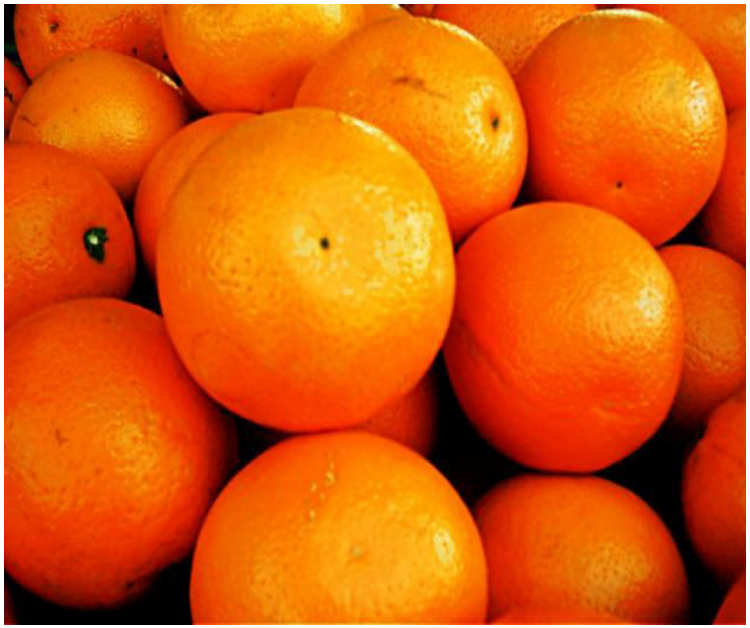
- Categories are abstract/schematic.
- Human beings have the ability to generalize.

Relationships between categories

Hierarchical relations



Vertical relations



Similarity

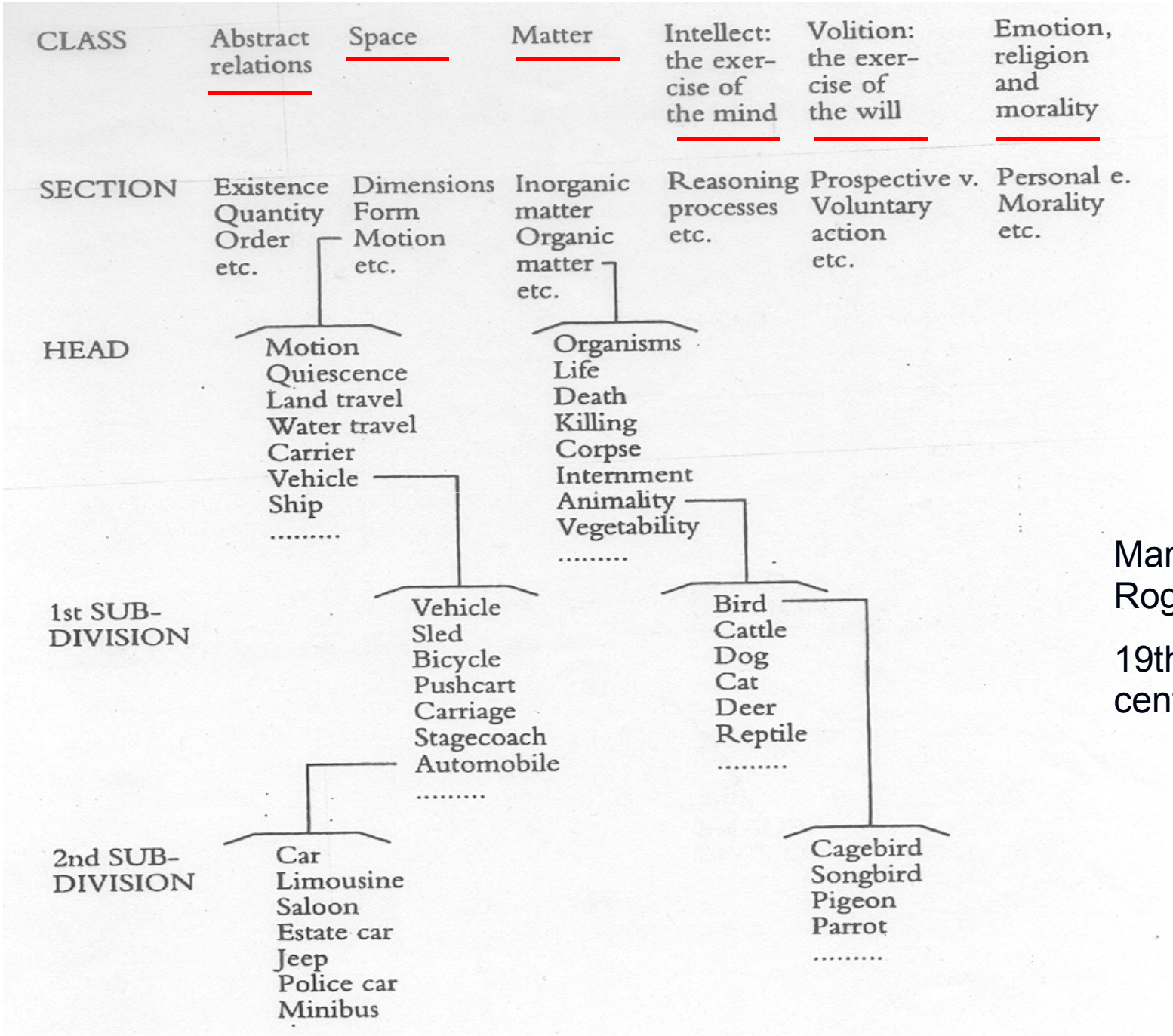
Apples and oranges:

- Color
- Shape
- Taste
- Weight
- Smell
- Juciness
- Price
- Healthiness
- Geographical distribution
- …

Similarity

Similarity calculations [Tversky 1977]

Taxonomies



Mark Roger

19th century

Taxonomy

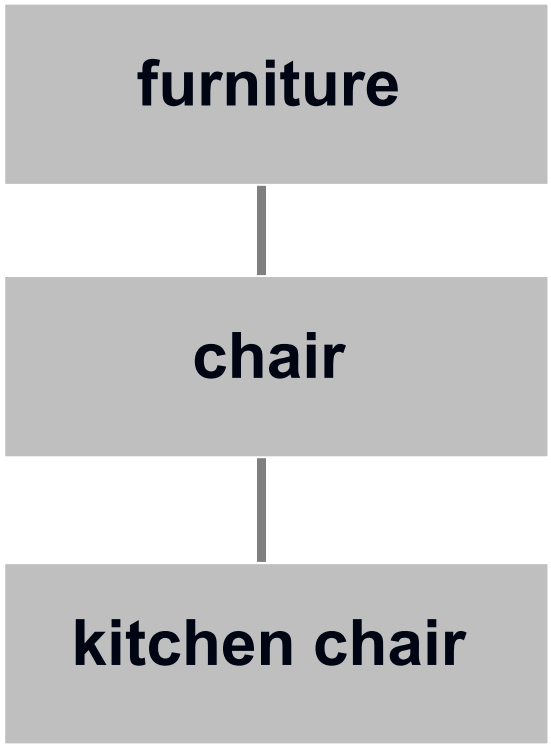
Is the taxonomic relationship between categories psychologically realistic?

Law of transitivity

If all As are Bs, and all Bs are Cs,

then all As must be Cs.

Law of transitivity

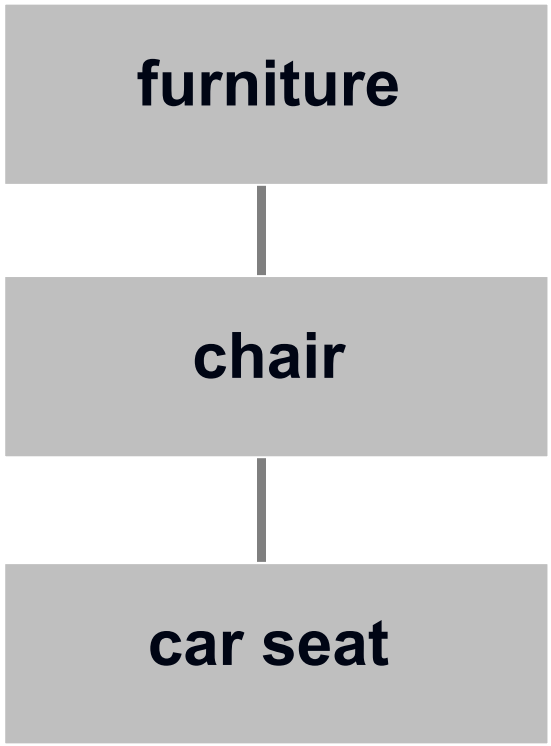


Thus, a kitchen chair is furniture.

A chair is furniture.

A kitchen chair is a type of chair.

Law of transitivity



But a car seat is not furniture.

A chair is furniture.

A car seat is a type of chair.

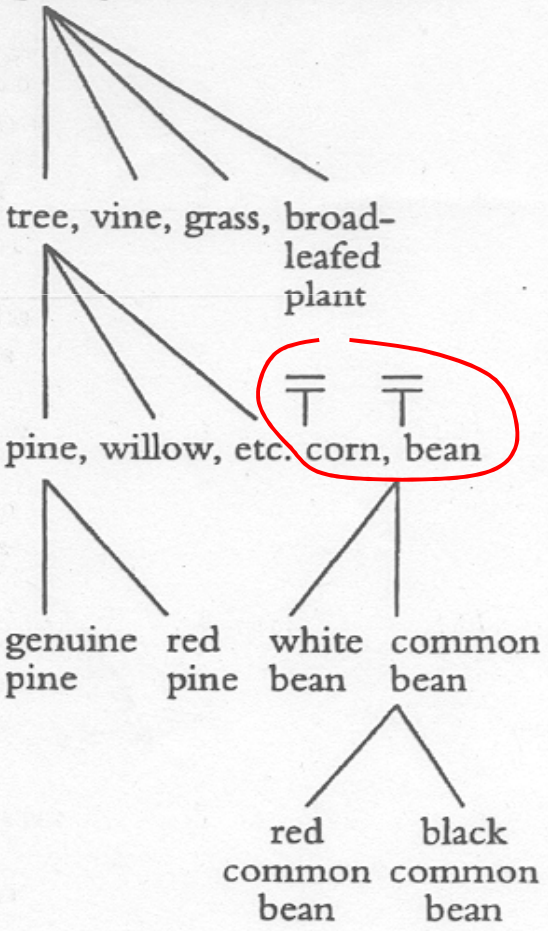
Folk taxonomies

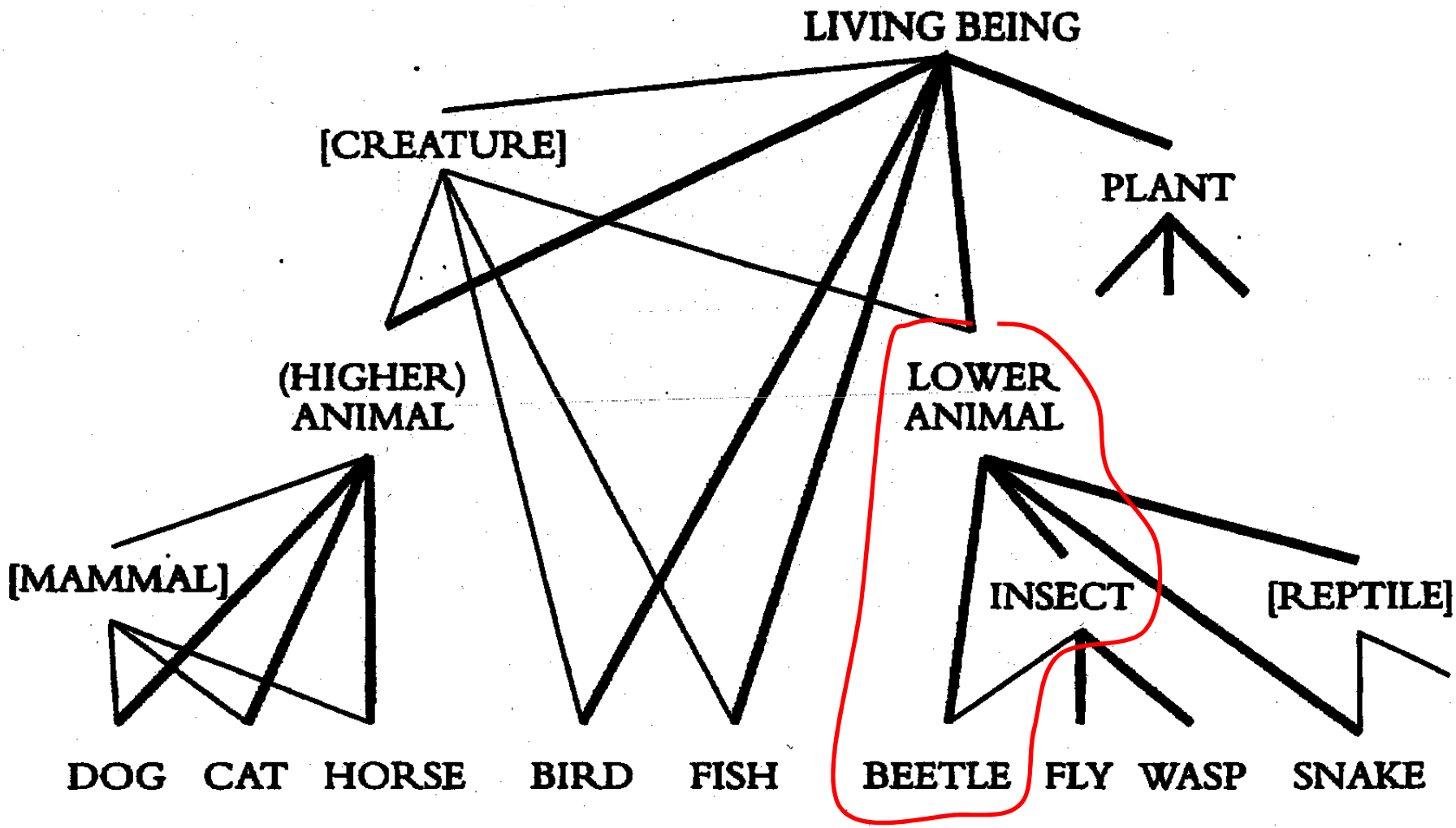
Brent Berlin

1969

TZELTAL PLANT CLASSIFICATION

SCIENTIFIC BIOLOGICAL CLASSIFICATION	Levels	number of categories	inclusion in superordinate category	examples [in translation]
regnum	1 unique beginners	1		[plant] unlabelled in Tzeltal
('kingdom') divisio phylum				
class	2 life form	4	100%	tree, vine, grass, broad-leafed plant
ordo familia tribus				
genus	3 generic	471	75%	pine, willow, etc. corn, bean
sectio series				
species	4 specific	273	100%	genuine pine; red pine; white bean; common bean
varietas	5 varietal	8	100%	red common bean; black common bean
forma				



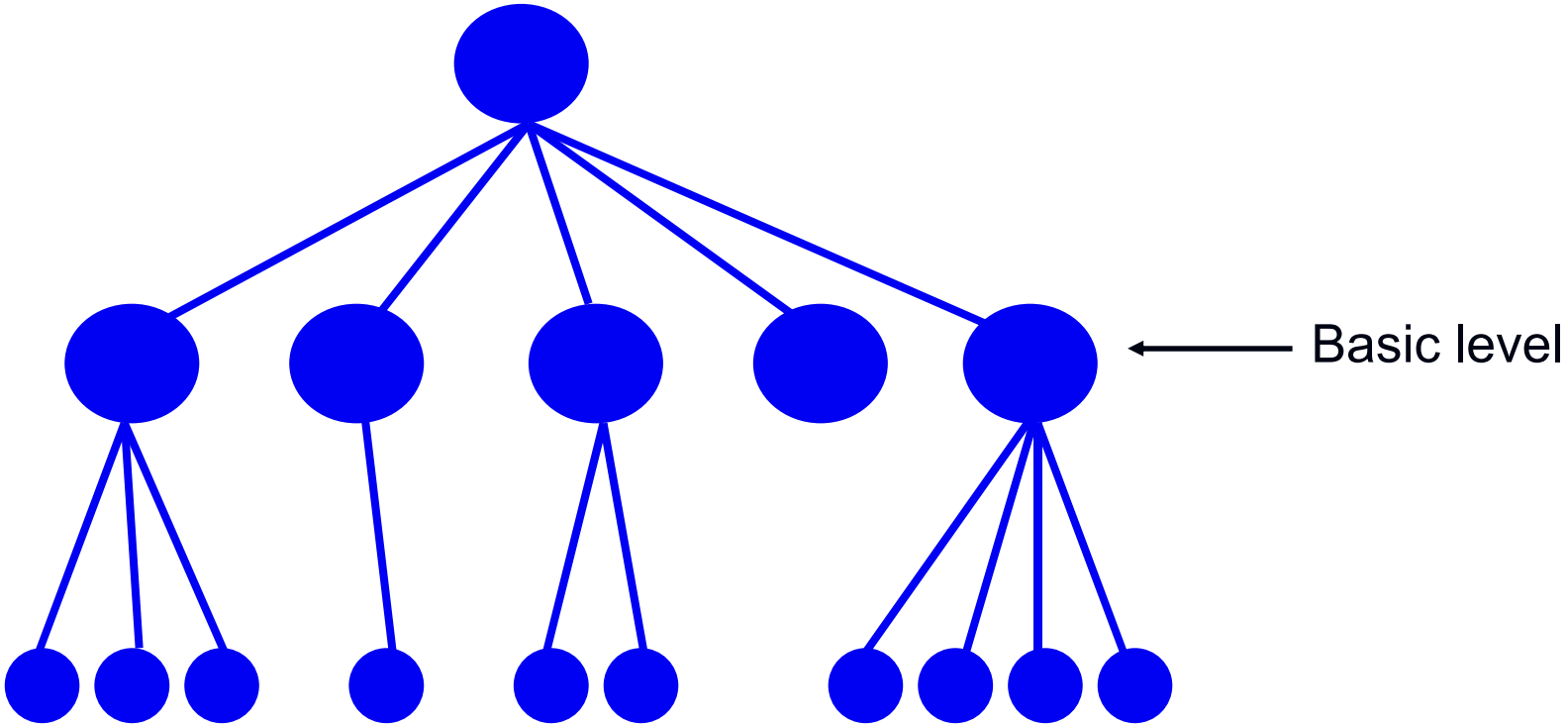

LIVING BEING
[CREATURE]
PLANT
(HIGHER)
ANIMAL
LOWER
ANIMAL
[MAMMAL]
INSECT
[REPTILE]
DOG
CAT
HORSE
BIRD
FISH
BEETLE
FLY
WASP
SNAKE

Folk taxonomies

Folk taxonomies:

- Are less complex than scientific taxonomies
- Are less consistent than scientific taxonomies
- Have a basic level

Basic level categories



List features

plant

- green

tree

- green
- leaves
- stem
- roots
- bark

oak tree

- green
- leaves
- stem
- roots
- bark
- acorn

Consider category names

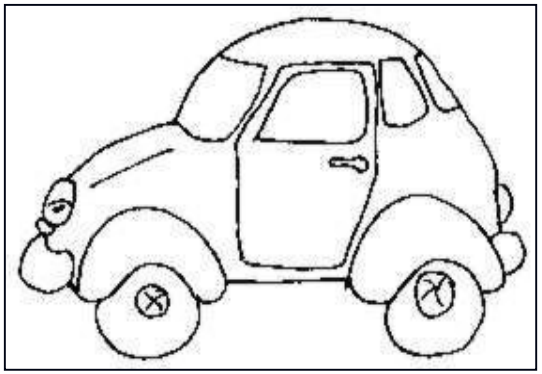
superordinate	basic level	subordinate
■ plant	■ tree	■ oak tree
■ animal	■ dog	■ bulldog
■ vehicle	■ car	■ sports car
■ insect	■ fly	■ horsefly
■ liquid	■ water	■ mineral water

Draw pictures

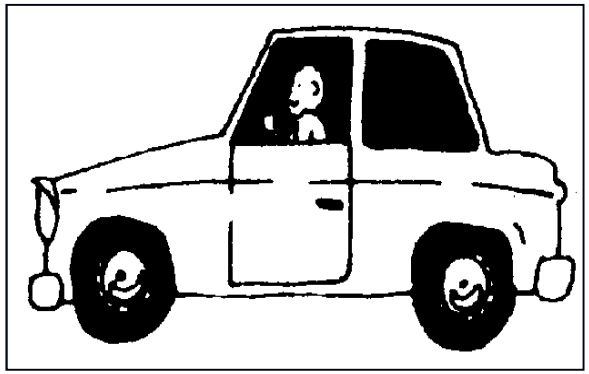
1. vehicle – car – police car
2. animal – dog – German shepherd

Draw pictures

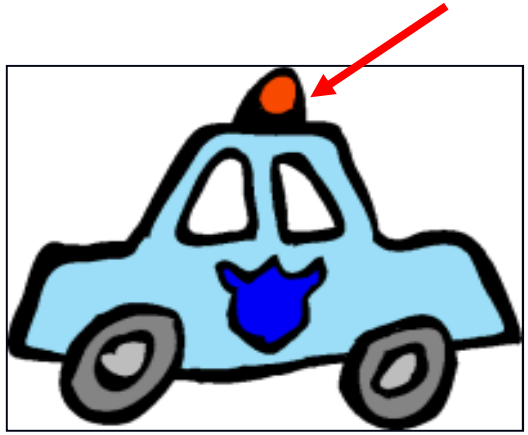
vehicle



car

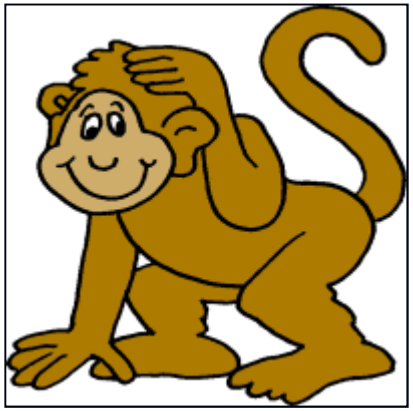


police car

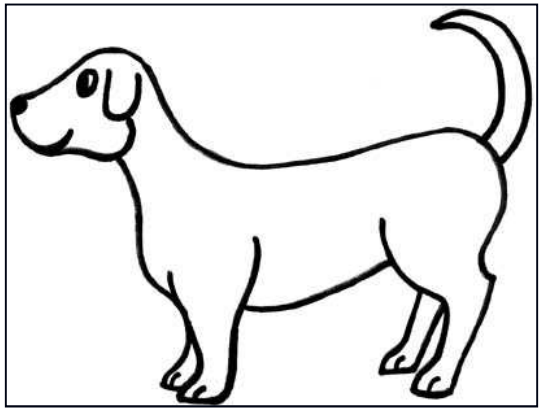


Draw pictures

animal



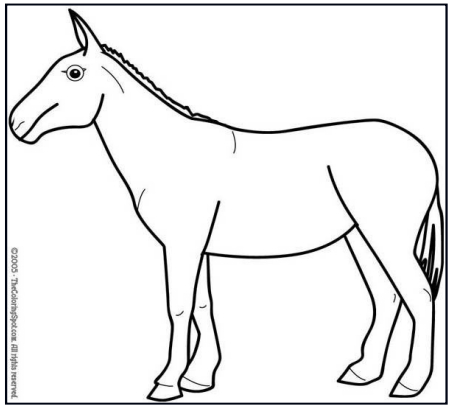
dog



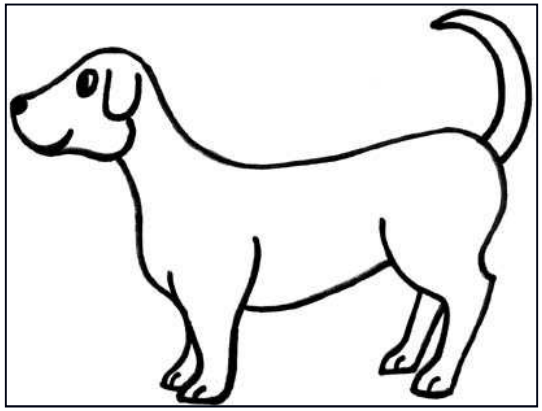
shepherd

Draw pictures

animal



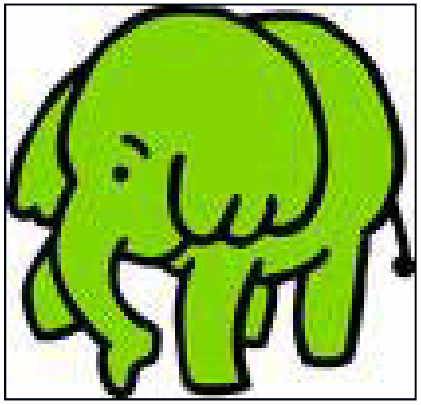
dog



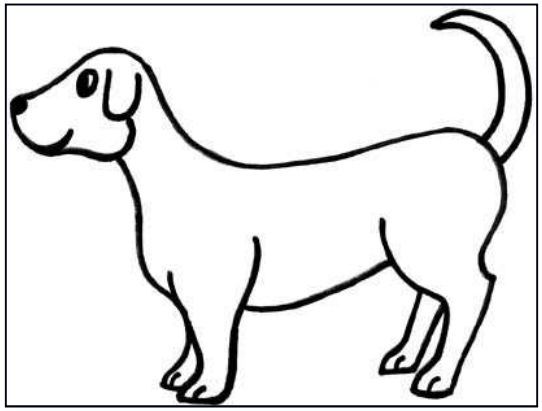
shepherd

Draw pictures

animal



dog



shepherd

Provide a gesture

What do you do with a chair?

Provide a gesture

What do you do with furniture?

Basic level categories

- Elaborate concept: many features
- Short and frequent linguistic form
- Concrete entity (usually)

Basic level categories

Categories of different levels serve different functions in communication and cognition:

- Basic level categories provide natural access to the world
- Subordinate level categories differentiate between similar entities
- Superordinate level categories help us to organize the world.

Basic level categories

News paper	>	newspaper
Air plane	>	plane
Holy day	>	holiday
Automobil	>	auto
Omnibus	>	bus

Basic level categories

Experts have often different basic level categories:

Car dealer: sports car, family van

In Tzeltal *pine* and *willow* are basic level categories.

What are they in English?

Basic level categories

	Gestalt
Basic level categories	Common gestalt
Superordinate categories	
Subordinate categories	

Basic level categories

	Gestalt
Basic level categories	Common gestalt
Superordinate categories	No common gestalt
Subordinate categories	

Basic level categories

	Gestalt
Basic level categories	Common gestalt
Superordinate categories	No common gestalt
Subordinate categories	Minimally different from basic level

Basic level categories

	Gestalt	Attribute
Basic level categories	Common gestalt	Large number of attributes
Superordinate categories	No common gestalt	
Subordinate categories	Minimally different from basic level	

Basic level categories

	Gestalt	Attribute
Basic level categories	Common gestalt	Large number of attributes
Superordinate categories	No common gestalt	Few attributes
Subordinate categories	Minimally different from basic level	

Basic level categories

	Gestalt	Attribute
Basic level categories	Common gestalt	Large number of attributes
Superordinate categories	No common gestalt	Few attributes
Subordinate categories	Minimally different from basic level	Large number of attributes

Basic level categories

	Gestalt	Attribute	Linguistic form
Basic level categories	Common gestalt	Large number of attributes	
Superordinate categories	No common gestalt	Few attributes	
Subordinate categories	Minimally different from basic level	Large number of attributes	

Basic level categories

	Gestalt	Attribute	Linguistic form
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic
Superordinate categories	No common gestalt	Few attributes	
Subordinate categories	Minimally different from basic level	Large number of attributes	

Basic level categories

	Gestalt	Attribute	Linguistic form
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic
Superordinate categories	No common gestalt	Few attributes	Morphologically more complex, academic
Subordinate categories	Minimally different from basic level	Large number of attributes	

Basic level categories

	Gestalt	Attribute	Linguistic form
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic
Superordinate categories	No common gestalt	Few attributes	Morphologically more complex, acedemic
Subordinate categories	Minimally different from basic level	Large number of attributes	Compounds, noun-adjective phrases

Basic level categories

	Gestalt	Attribute	Linguistic form	Function
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic	
Superordinate categories	No common gestalt	Few attributes	Morphologically more complex, academic	
Subordinate categories	Minimally different from basic level	Large number of attributes	Compounds, noun-adjective phrases	

Basic level categories

	Gestalt	Attribute	Linguistic form	Function
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic	'Natural' access to the world
Superordinate categories	No common gestalt	Few attributes	Morphologically more complex, academic	
Subordinate categories	Minimally different from basic level	Large number of attributes	Compounds, noun-adjective phrases	

Basic level categories

	Gestalt	Attribute	Linguistic form	Function
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic	'Natural' access to the world
Superordinate categories	No common gestalt	Few attributes	Morphologically more complex, academic	Highlighting + Collecting
Subordinate categories	Minimally different from basic level	Large number of attributes	Compounds, noun-adjective phrases	

Basic level categories

	Gestalt	Attribute	Linguistic form	Function
Basic level categories	Common gestalt	Large number of attributes	Monomorphemic	'Natural' access to the world
Superordinate categories	No common gestalt	Few attributes	Morphologically more complex, academic	Highlighting + Collecting
Subordinate categories	Minimally different from basic level	Large number of attributes	Compounds, noun-adjective phrases	Specifying

Assignment

Design a short questionnaire in order to investigate the structure of a category of your choice. Aspects that you could explore: (i) the prototype(s), (ii) aspects of the prototype (i.e. what is important, color, shape, purpose?), (iii) relationships between category members, (iv) taxonomic organization.

Questions

- Define the meaning of the word ‘weapon’ and explain why most people think a ‘gun’ is a better instance of a weapon than a ‘knife’, and why some people think that ‘fists’ are weapons. Please refer to the three aspects psychologist proposed to define the notion of prototype in your answer.
- Explain why research on color perception seems to support prototype theory.
- What is the difference between the notion of necessary and sufficient features and a structured feature list? Use the category ‘dog’ as an example to explain your answer.
- Like other scientists, linguists use categories such as ‘word’, ‘phoneme’ and ‘noun’ to describe the phenomenon they study, i.e. language. Is prototype theory of any relevance for linguistics, i.e. can linguistic categories be seen as prototypes?

Questions

- In some theories categories are defined as ‘token clusters’. Explain.
- Discuss the relationship between prototype theory and exemplar theory.
- What is a folk taxonomy?
- A folk taxonomy has usually three levels, the basic level, the superordinate level, and the subordinate level. What characterizes the basic level?