Classical View of Concepts (well-defined categories)

- defining features for category membership
- properties are necessary and sufficient
- equivalence class – all exemplars are equal

E.g. bird - an animal with feathers, that flies, breathes air and lays eggs
\[ \psi_{\text{circle}}(X) = \begin{cases} 
1 & \text{if the figure } X \text{ is a circle,} \\
0 & \text{if the figure is not a circle.} 
\end{cases} \]

\[ \psi_{\text{convex}}(X) = \begin{cases} 
1 & \text{if } X \text{ is a convex figure,} \\
0 & \text{if } X \text{ is not a convex figure;} 
\end{cases} \]

\[ \psi_{\text{connected}}(X) = \begin{cases} 
1 & \text{if } X \text{ is a connected figure,} \\
0 & \text{otherwise.} 
\end{cases} \]
Early concept learning: Hull (1920)

How do concepts develop from exposure to instances of a concept?

first experimental study on concept learning that relies on behavioral data
learning depends on ability to generalize from simple concepts to more complex

<table>
<thead>
<tr>
<th>Name</th>
<th>Concept</th>
<th>Pack I</th>
<th>Pack II</th>
<th>Pack III</th>
<th>Pack IV</th>
<th>Pack V</th>
<th>Pack VI</th>
</tr>
</thead>
<tbody>
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<td>晚师师讲提讲</td>
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</tbody>
</table>

From Hull (1920)
Bruner, Goodnow, & Austin (1956) concepts are based on rules. Focus on strategies used by subjects to determine category membership.
Bruner, Goodnow, & Austin (1956)

participants asked to identify concepts – figures on cards
figures vary along 4 dimensions – 81 separate figures
• form – cross, circle, or square
• color – green, red, or black
• number – 1, 2, or 3 forms
• border – 1, 2, or 3 lines
Bruner, Goodnow, & Austin (1956)

experimenter chooses arbitrary rule to define concept
- e.g., contains red or a cross

participant’s task is to discover rule relating category membership
Bruner, Goodnow, & Austin (1956)
Bruner, Goodnow, & Austin (1956)

Figure 8.5. Average number of trials to solution for four different logical rules. (From “Knowing and Using Concepts,” by L. E. Bourne, Jr. In Psychological Review, 1970, 77, 546–556. Copyright 1970 by the American Psychological Association. Reprinted by permission.)
Bruner, Goodnow, & Austin (1956)

trade-off between risk of hypothesis, time required to determine rule, & limitations of STM

- reception strategies
  - "wholist" → select intersection of hits
  - "partist" → test hypotheses

- selection strategies
  - "scanning" → test hypotheses; and
  - "focusing" → use positive instance as anchor
Shepard, Hovland, and Jenkins (1961) interested in factors influencing concept learning

- concept complexity
- selective attention
Shepard, Hovland, and Jenkins (1961)

Fig. 1. Six different classifications of the same set of eight stimuli. (Within each box the four stimuli on the left belong in one class and the four stimuli on the right in the other class.)
Shepard, Hovland, and Jenkins (1961)
Shepard, Hovland, and Jenkins (1961)

Data from Nosofsky (unpublished). Plotted are the total number of errors.
Shepard, Hovland, and Jenkins (1961)

- response time and errors increased with increasing complexity
- subjects were able to selectively attend to relevant features
Problems with Classical View

- Boolean rules with more disjunctive terms are harder for subjects to learn and generalize

- natural categories composed of probabilistic features and membership

- What is a “game”? (Wittgenstein)
Ill-defined (naturalistic) categories

no necessary and sufficient features
Ill-defined categories

Implications:

1. some members of the category are better members (more representative) than other members

2. category boundaries are graded and “fuzzy”

3. learning a category does not involve learning a “rule”

4. abstraction is moving higher in a natural taxonomy of category types
Rosch (1975)

(a) Category = birds

(b) Category = furniture
## TABLE 8.1. Examples of Subordinate, Basic, and Superordinate Categories.

<table>
<thead>
<tr>
<th>Superordinate</th>
<th>Basic level</th>
<th>Subordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musical instrument</td>
<td>Guitar</td>
<td>Folk guitar</td>
</tr>
<tr>
<td></td>
<td>Piano</td>
<td>Grand piano</td>
</tr>
<tr>
<td></td>
<td>Drum</td>
<td>Kettle drum</td>
</tr>
<tr>
<td>Fruit</td>
<td>Apple</td>
<td>Delicious apple</td>
</tr>
<tr>
<td></td>
<td>Peach</td>
<td>Freestone peach</td>
</tr>
<tr>
<td></td>
<td>Grapes</td>
<td>Concord grapes</td>
</tr>
<tr>
<td>Tool</td>
<td>Hammer</td>
<td>Ball-peen hammer</td>
</tr>
<tr>
<td></td>
<td>Saw</td>
<td>Hack hand saw</td>
</tr>
<tr>
<td></td>
<td>Screwdriver</td>
<td>Phillips screwdriver</td>
</tr>
<tr>
<td>Clothing</td>
<td>Pants</td>
<td>Levi’s</td>
</tr>
<tr>
<td></td>
<td>Socks</td>
<td>Knee socks</td>
</tr>
<tr>
<td></td>
<td>Shirt</td>
<td>Dress shirt</td>
</tr>
<tr>
<td>Furniture</td>
<td>Table</td>
<td>Kitchen table</td>
</tr>
<tr>
<td></td>
<td>Lamp</td>
<td>Floor lamp</td>
</tr>
<tr>
<td></td>
<td>Chair</td>
<td>Kitchen chair</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Car</td>
<td>Sports car</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>City bus</td>
</tr>
<tr>
<td></td>
<td>Truck</td>
<td>Pick-up truck</td>
</tr>
</tbody>
</table>

Rosch, Simpson, et al. (1976)

in a categorization task Ss were faster to identify objects that were cued with basic-level label

e.g., faster to respond to a picture of a “chevy sedan” when “car” used rather than “vehicle”
TABLE 8.2 Number of Attributes in Common at Each Hierarchical Level.

<table>
<thead>
<tr>
<th>Category</th>
<th>Raw tallies</th>
<th></th>
<th></th>
<th>Judge-amended tallies</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Super-ordinate</td>
<td>Basic</td>
<td>Sub-ordinate</td>
<td>Super-ordinate</td>
<td>Basic</td>
<td>Sub-ordinate</td>
</tr>
<tr>
<td>Musical instrument</td>
<td>1</td>
<td>6.0</td>
<td>8.5</td>
<td>1</td>
<td>8.3</td>
<td>8.7</td>
</tr>
<tr>
<td>Fruit</td>
<td>7</td>
<td>12.3</td>
<td>14.7</td>
<td>3</td>
<td>8.3</td>
<td>9.5</td>
</tr>
<tr>
<td>Tool</td>
<td>3</td>
<td>8.3</td>
<td>9.7</td>
<td>3</td>
<td>8.7</td>
<td>9.2</td>
</tr>
<tr>
<td>Clothing</td>
<td>3</td>
<td>10.0</td>
<td>12.0</td>
<td>2</td>
<td>8.3</td>
<td>9.7</td>
</tr>
<tr>
<td>Furniture</td>
<td>3</td>
<td>9.0</td>
<td>10.3</td>
<td>0</td>
<td>7.0</td>
<td>7.8</td>
</tr>
<tr>
<td>Vehicle</td>
<td>4</td>
<td>8.7</td>
<td>11.2</td>
<td>1</td>
<td>11.7</td>
<td>16.8</td>
</tr>
</tbody>
</table>


TABLE 8.3. Examples of Shared Attributes at Different Hierarchical Levels.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Clothing</th>
<th>Furniture</th>
</tr>
</thead>
<tbody>
<tr>
<td>make things</td>
<td>you wear it</td>
<td>no attributes</td>
</tr>
<tr>
<td>fix things</td>
<td>keeps you warm</td>
<td></td>
</tr>
<tr>
<td>metal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saw</td>
<td>Legs</td>
<td>Chair</td>
</tr>
<tr>
<td>handle</td>
<td>buttons</td>
<td>legs</td>
</tr>
<tr>
<td>teeth</td>
<td>belt loops</td>
<td>seat</td>
</tr>
<tr>
<td>blade</td>
<td>pockets</td>
<td>back</td>
</tr>
<tr>
<td>sharp</td>
<td>cloth</td>
<td>arms</td>
</tr>
<tr>
<td>cuts</td>
<td>two legs</td>
<td>comfortable</td>
</tr>
<tr>
<td>edge</td>
<td>Levi’s blue</td>
<td>four legs</td>
</tr>
<tr>
<td>wooden handle</td>
<td></td>
<td>wood</td>
</tr>
<tr>
<td>Cross-cutting</td>
<td>Double-knit pants</td>
<td>holds people—</td>
</tr>
<tr>
<td>hand saw</td>
<td>comfortable</td>
<td>you sit on it</td>
</tr>
<tr>
<td>used in construction</td>
<td>stretchy</td>
<td></td>
</tr>
<tr>
<td>Hack hand saw</td>
<td>no additional</td>
<td>Kitchen chair</td>
</tr>
<tr>
<td>no additional</td>
<td></td>
<td>no additional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Living-room chair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>large</td>
</tr>
<tr>
<td></td>
<td></td>
<td>soft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cushion</td>
</tr>
</tbody>
</table>
Rosch (1976)

Basic-level categories have special status

- contain the most information
- share more attributes
- have shapes in common
- are used to identify objects
- produce priming effect
- are first learned by children
- experts use subordinate level as basic level
Rosch (1976)

- family resemblance
  - probabilistic features

- typicality
  - exemplars differ along typicality scale

- prototype
  - averaged over exemplars
How to test category learning of ill-defined categories?

most naturalistic categories are already known

simulate “naturalistic” categories with statistical distance rules
Figure 8.9. Distortions of a prototype (original) pattern at different levels of variability. (From “Perceived Distance and the Classification...”)

Posner & Keele (1968)
Posner & Keele (1968)

- more errors with high distortion or average distance from prototype

- more errors with new patterns then old patterns

- more errors with new patterns then Prototype

- after several days prototype no worse then old patterns and is with many subjects better than old or new patterns
Figure 1. A prototypical form, surrounded by emplars of varying distortion (low, medium, high) from the prototype.
Homa (1970s)
Shepard – similarity in psychological space is exponential
Prototype

- central tendency of exemplars
- implicit "rule"
What about an abstract concept?
Oosterhof and Todorov (2008) - Trustworthiness

Have you got the look?
According to Alexander Todorov of Princeton University, our snap judgements of faces are based on an "overgeneralisation" of an evolved need to read facial expressions for signs of danger.

In these computer-generated images, the emotionally neutral face in the middle has been morphed to show the typical characteristics that make a face look more or less trustworthy and dominant.

[Diagram showing a grid of faces along dimensions of trustworthiness and dominance]
Oosterhof and Todorov (2008) – Trustworthiness

- people evaluate faces on multiple trait dimensions
- high between subject consensus
- valence & dominance → trustworthiness
Oosterhof and Todorov (2008) - Trustworthiness

A face you can trust

Princeton psychologists recently showed that certain faces, even when emotionless, strike people as trustworthy or untrustworthy. Features like the shape of the eyebrow are part of an unconscious language of trust that powerfully affects human interaction.

Features that appear untrustworthy:
- Low inner eyebrows
- Shallow indentation
- Shallow cheekbones
- Thin chin

Features that appear trustworthy:
- High inner eyebrows
- Shallow indentation
- Pronounced cheekbones
- Wide chin

Sources: Alexander Todorov, Sean G. Ellis, and Nikolas N. Oosterhof, Princeton University
Problems with prototypes:

no information about category variance, feature correlation category size etc..

certain members seems very important - ROBIN vs BIRD prototype - What is the difference?

conceptual combinations:  pet fish prototype “pet” <> prototype “fish”

average assumes linear separable categories - many categories are not linearly separable

How to use context?
Exemplar model

concepts are characterized by specific members, not an average explicit association of exemplars to concept
e.g., alphabet has no prototypical letter – alphabet known by members
Medin & Schaffer (1978)

Context Model

category membership based on the closest set of exemplars to the test stimulus based on feature similarity
various exemplar models

Figure 9-3: Clustering examples illustrating three different but commonly used methods for determining group membership: (a) nearest neighbor, (b) farthest neighbor, (c) centroid
different exemplar strategies $\rightarrow$ different categories
hard to differentiate between “exemplar similarity” and a prototype (rule based)

- both dependent on features
- both dependent on similarity
- both dependent on category structure
• exemplars used during early learning
• prototypes develop with experience

similar to episodic → semantic?