Reading:

Trevor Harley’s The Psychology of Language, Chapter 10
Recap: Categorization

*Categorization* is one of the classical problems in the field of cognitive science, one with a history dating back to Aristotle.

- Ability to generalize from experience underlies a variety of common mental tasks
- Perception, learning, and the use of language.
- Definitional, prototype, exemplar, and theories theory.
- Basic-level categories, prototype, family resemblance.
Semantic knowledge can be thought of as knowledge about relations among several types of elements, including words, concepts, and percepts.
Knowledge that the word *dog* refers to the concept **DOG** the word *animal* refers to the concept **ANIMAL** or the word *toaster* refers to the concept **TOASTER**.
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Knowledge that the word *dog* refers to the concept **DOG** the word *animal* refers to the concept **ANIMAL** or the word *toaster* refers to the concept **TOASTER**.
Knowledge that *dogs* are a kind of animal, that *dogs* have tails and can bark, or that *animals* have bodies and can move.

ANIMAL
  IS-A
  VERTEBRATE
    IS-A
    MAMMAL
      IS-A
      CANINE
        IS-A
        DOG
Knowledge about what dogs look like, how a dog can be distinguished from a cat, or how to pet a dog or operate a toaster.
Knowledge that the word *dog* tends to be associated with or co-occur with words such as *tail*, *bone*, and *cat* or that the word *toaster* tends to be associated with *kitchen*, *oven*, or *bread*. 

What are the associates of *apple*? *red*, *orange*, *pie*, *worm*.
Knowledge that the word *dog* tends to be associated with or co-occur with words such as *tail, bone, and cat* or that the word *toaster* tends to be associated with *kitchen, oven, or bread*.

What are the associates of *apple*?
Knowledge that the word *dog* tends to be associated with or co-occur with words such as *tail, bone, and cat* or that the word *toaster* tends to be associated with *kitchen, oven, or bread.*

**What are the associates of *apple***?

red  orange  pie  worm
Semantic Networks

- Emphasizes abstract conceptual structure, focusing on relations among concepts and relations between concepts and percepts or actions.

- This knowledge is represented in terms of systems of abstract propositions, such as *canary is-a bird, canary has bird wings*.

- Concepts represented in network of interconnecting nodes

- Distance between nodes represents similarity between them.

- Concept defined in terms of the connections with other concepts
Useful for representing natural kind terms.

Economical method for storing information.

Most common links are IS-A links

Attributes stored at lowest possible node at which they are true of all lower nodes in network
Sentence Verification Task

Participants are presented with simple “facts” and have to press one button if the sentence is true, another if it is false. The reaction time is an index of how difficult the decision was.

(1) A robin is a robin.
(2) A robin is a bird.
(3) A robin is an animal.
(4) A robin is a fish.

Response time to (1) < (2) < (3) < (4). Participants start off from robin and travel through the network until they find the necessary information. The farther away the information the slower the response time.
Sentence Verification Task

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Sentence Verification Task

ANIMAL

IS-A

BIRD

IS-A

ROBIN

IS-A

PIG

IS-A

MAMMAL

IS-A

PENGUIN
A robin is a robin.
A robin is a bird.
A robin is an animal.
A robin is a fish.
Problems with the Collins and Quillian Model

- Not all information is easily represented in hierarchical form (what is the relation between *truth*, *justice*, and *law*)?
- Experiments confound distance in network with conjoint frequency (*robin* and *bird* often co-occur).
- The model makes some incorrect predictions: (5) < (6), (7) < (8), (9) < (10).

(5) A cow is an animal.
(6) A cow is a mammal.
(7) A pine is a church.
(8) A pine is a flower.
(9) A robin is a bird.
(10) A penguin is a bird.
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<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<tr>
<td>(6)</td>
<td>A cow is a mammal.</td>
</tr>
<tr>
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Collins and Loftus (1975)

- Model is based on idea of spreading activation.
- More complex network structure with links varying in strength or distance; structure is no longer hierarchical.
- Connections represent: categorical relations, degree of association, typicality.
- When you think about a concept, that concept will become activated, and that activation will spread to other concepts that are linked to it.
- Verification times depend on closeness concepts in network.
- Hard to see what sort of experiments could falsify this model.
Collins and Loftus (1975)

- street
- vehicle
- car
- bus
- truck
- fire engine
- orange
- red
- blue
- roses
- tulips
- flowers
- apple
- fruit
- pear
- house
- fire

Informatics 1 CG: Lecture 11 Word Meaning
### Feature Comparison Model

<table>
<thead>
<tr>
<th>Animal</th>
<th>animate</th>
<th>feathered</th>
<th>has_a_beak</th>
<th>flies</th>
<th>sings</th>
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<tbody>
<tr>
<td>BIRD</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>ROBIN</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>PENGUIN</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PIG</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Concepts are represented as a set of **features**.
- Features are ordered in terms of **definingness**.¹
- **Defining features**: essential to meaning of word and relate to properties that things must have to be members of category.
- **Characteristic features**: are usually but not necessarily true (most birds can fly but penguins and ostriches cannot).

¹Distinction between defining and characteristic features is arbitrary.
Concepts are represented as a set of features.

- Features are ordered in terms of definingness.¹
- **Defining features**: essential to meaning of word and relate to properties that things must have to be members of category.
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¹Distinction between defining and characteristic features is arbitrary.
A robin is a bird.
A robin is a bird.

**Stage 1**

Compare **all features** of robin and bird to determine featural similarity.
A robin is a bird.

Stage 1
Compare all features of robin and bird to determine featural similarity.

High Overlap
Fast yes
A robin is a pig.

**Stage 1**

Compare all features of robin and pig to determine featural similarity.
A penguin is a bird.

Stage 1

Compare all features of penguin and bird to derive feature similarity.
A penguin is a bird.

**Stage 1**
Compare *all features* of penguin and bird to determine featural similarity.

**Stage 2**
Compare *defining features* to determine featural similarity.

Slow yes
Many words do not have obvious defining features!
Model is tied to sentence verification paradigm.
Probabilistic feature model (Smith and Medin, 1981).
Distinguishes between essential defining features of concepts and aspects of meaning for identifying instances of concept.
Features are weighted based on salience and probability of being true for category (has four limbs vs bears live young).
Candidate instance is accepted if exceeds some critical weighted sum of features.
Categories now have fuzzy boundaries.
How is this model different from prototype model?
Where Do the Features Come from?

- Participants are presented with set of concept names
- Asked to write down up to $n$ features they think are important for each concept
- McRae et al (2005) collected feature norms for 541 living and nonliving concepts
- Largest set in existence (2,526 features), collected over several years
- Reveal psychologically salient dimensions of meaning
Where Do the Features Come from?

Feature norms from McRae et al. (2005).
Where Do the Features Come from?

MOOSE/ELK

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Where Do the Features Come from?

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<table>
<thead>
<tr>
<th>Feature</th>
<th>Freq</th>
<th>Classification</th>
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<td>visual</td>
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<td>has_antlers</td>
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<td>visual</td>
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<tr>
<td>has_legs</td>
<td>14</td>
<td>visual</td>
</tr>
<tr>
<td>is_brown</td>
<td>10</td>
<td>visual</td>
</tr>
<tr>
<td>has_fur</td>
<td>7</td>
<td>visual</td>
</tr>
<tr>
<td>has_hooves</td>
<td>5</td>
<td>visual</td>
</tr>
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<td>eaten_as_meat</td>
<td>5</td>
<td>function</td>
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<tr>
<td>lives_in_woods</td>
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<tr>
<td>an_animal</td>
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<td>taxonomic</td>
</tr>
<tr>
<td>a_mammal</td>
<td>9</td>
<td>taxonomic</td>
</tr>
</tbody>
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Feature norms from McRae et al. (2005).
McRae spent 10 years collecting his feature norms!
(541 basic-level nouns).

What about verbs or abstract concepts (e.g., *move*, *peace*)?

But, humans naturally express word meaning using features.
Representing Word Meaning

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>eats_seeds</td>
<td>0.00</td>
</tr>
<tr>
<td>has_beak</td>
<td>0.00</td>
</tr>
<tr>
<td>has_claws</td>
<td>0.00</td>
</tr>
<tr>
<td>has_handlebar</td>
<td>0.30</td>
</tr>
<tr>
<td>has_wheels</td>
<td>0.32</td>
</tr>
<tr>
<td>has_wings</td>
<td>0.00</td>
</tr>
<tr>
<td>has_feathers</td>
<td>0.00</td>
</tr>
<tr>
<td>made_of_metal</td>
<td>0.06</td>
</tr>
<tr>
<td>made_of_wood</td>
<td>0.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
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<tbody>
<tr>
<td>TROLLEY</td>
<td></td>
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- McRae spent 10 years collecting his feature norms! (541 basic-level nouns).
- What about verbs or abstract concepts (e.g., move, peace)?
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What about verbs or abstract concepts (e.g., move, peace)?

But, humans naturally express word meaning using features.
How do we represent the meaning of words? How is semantic knowledge organized?

- Semantic information in encoded in networks of linked nodes.
- Collins and Quillian network emphasizes hierarchical relations and cognitive economy; sentence verification times.
- Does not explain similarity and relatedness effects.
- Spreading activation model does but is difficult to falsify.
- Word meaning can be decomposed into semantic features.
- Feature-list theories account for sentence verification times by postulating that we compare lists of defining and characteristic features.

Next lecture: associationist view of meaning, vector space model.