Semantic Representations

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COGS 4780

Write down the first 5-6 words that immediately come to mind

- paper

Write down the first 5-6 words that immediately come to mind

- window

Write down the first 5-6 words that immediately come to mind

- ambulance

Write down the first 5-6 words that immediately come to mind

- shirt

Write down the first 5-6 words that immediately come to mind

- bicycle

Write down the first 5-6 words that immediately come to mind

- purple

Write down the first 5-6 words that immediately come to mind

- apple

Write down the first 5-6 words that immediately come to mind

- balloon

Write down the first 5-6 words that immediately come to mind

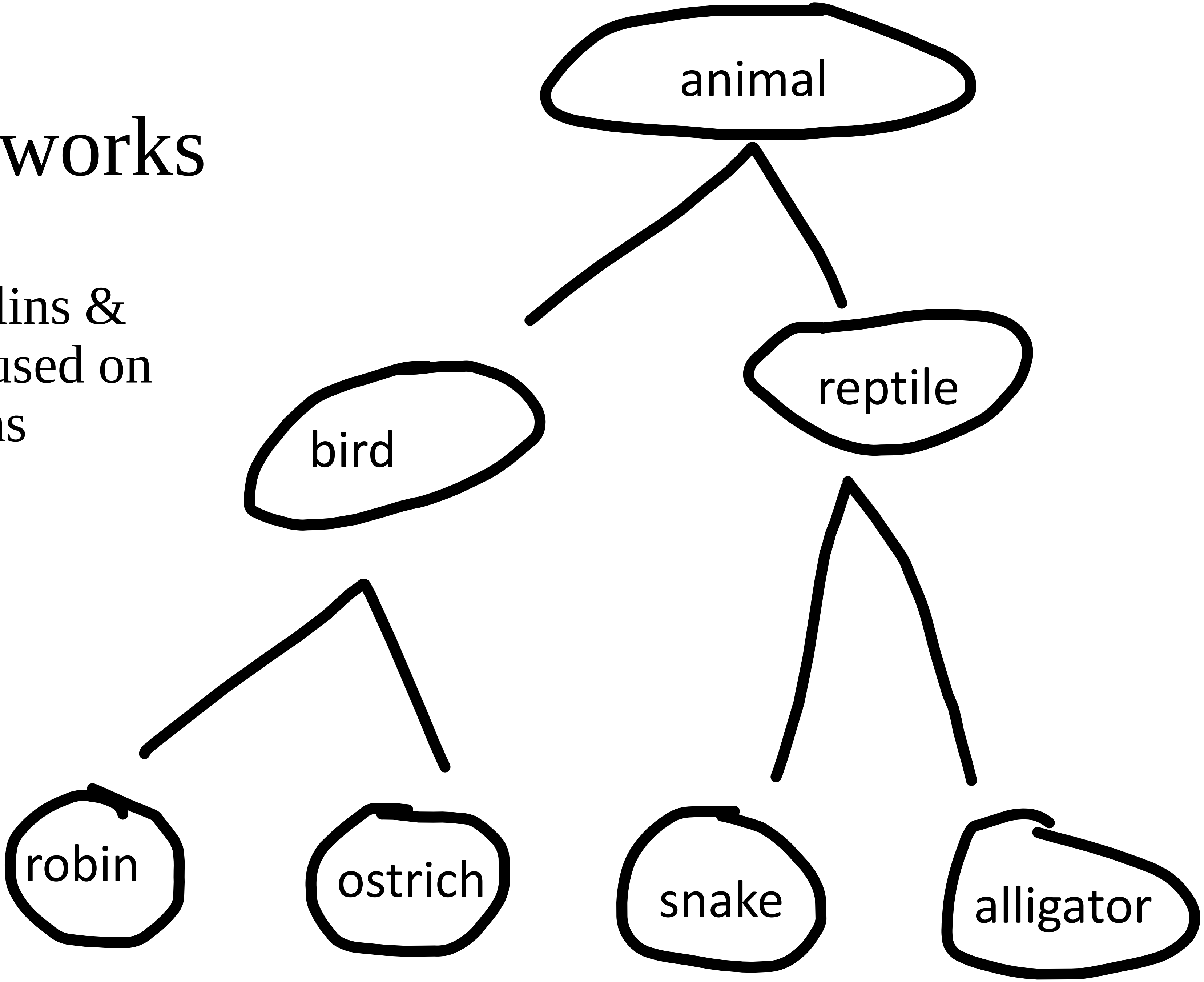
- fish

Semantic Networks

- So it’s useful to think of word meanings and semantics as set up in a network
- But how do we use that to get meaning?

Semantic Networks

- Early versions (Collins & Quillian, 1969) focused on hierarchical relations between items



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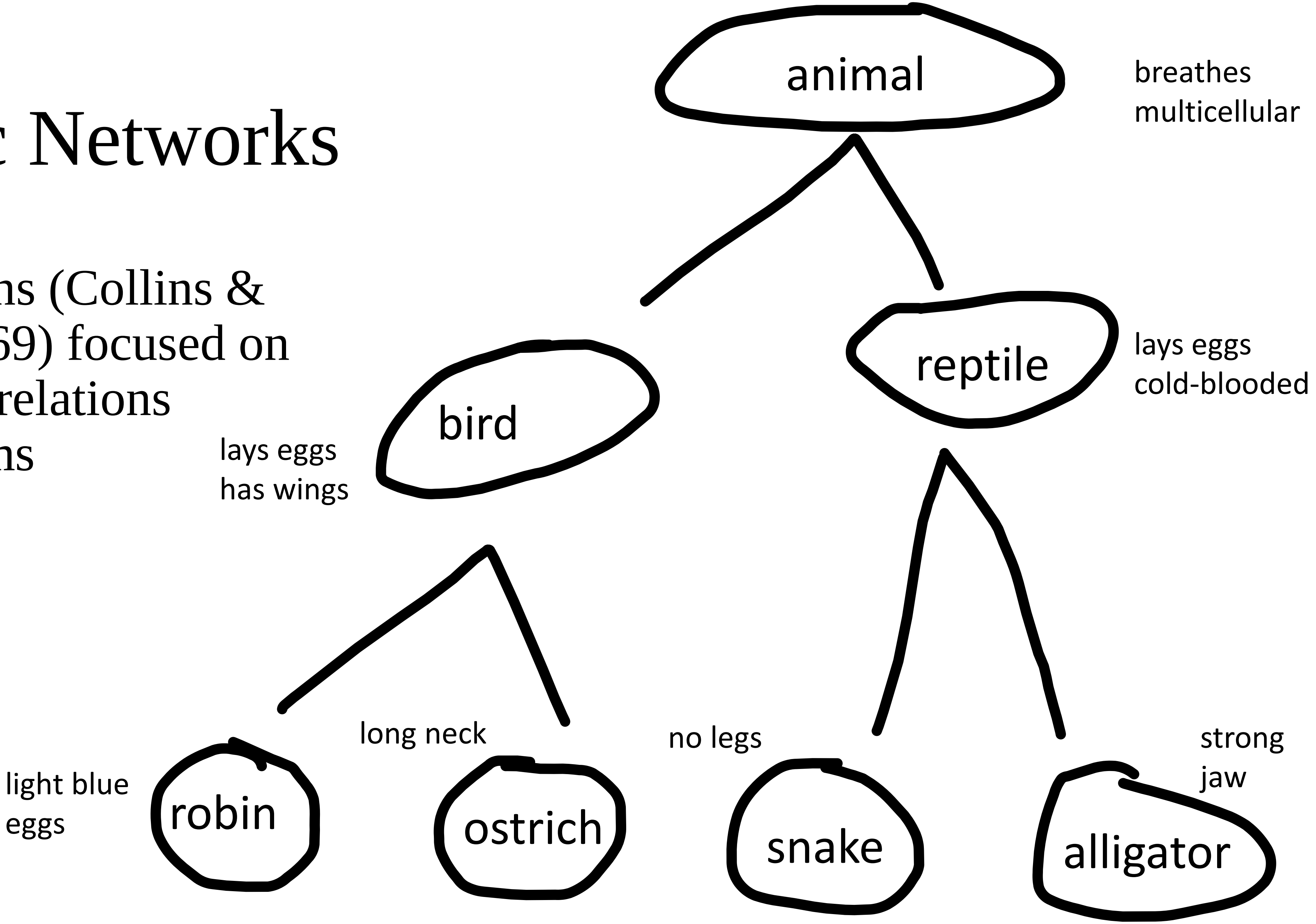

Semantic Networks

- Response time findings used to support this hierarchical setup

robin → bird

robin → bird → animal

snake → has no legs

snake ----------> breathes

- Because it travels a farther semantic distance, the second RTs should be slower than the first, and indeed they are

Semantic Networks

- Lots of problems with a model like this
- Not all terms can be related hierarchically
  - *truth*, *justice*, *law* are all related but not in a clear hierarchy
- Co-occurrence frequency better at explaining response times than semantic distance
  - “snake” appears more often with “no legs” than “breathes”
  - cow → mammal
  - cow → mammal → animal
    - But “a cow is an animal” is faster
- Not all items with the same semantic distance are recognized the same
  - robin → bird
  - penguin → bird

Semantic Networks

- Improved model: spreading activation
- Concepts and features all assembled in a network, each in a node
- Activation can spread throughout the network, activating relevant features
    - So it would take longer for activation to spread from “snakes” to “breathes” than “snakes” to “has no legs”

Semantic Features

- Another approach is the decompositional approach
- Here, words are made up entirely of features
- A certain set of “semantic primitives” can be used to distinguish between words

beat – “strike” [subject-human] [object-animate] [instrument-thing]

Semantic Features

The giraffe kicked the ball

The child kicked the ball

*The rock kicked the ball

- Features are governed by selection restrictions
- A selection restriction on *kick* establishes that it must have an animate subject and a physical object, so we can reject #3
- The presence of the verb *kick* allows us to disambiguate *ball*

Semantic Features

- This approach can help us explain the sentence verification findings, too
- *robin* has its own set of features
- *bird* has its own set of features
- In verifying “a robin is a bird” we compare these two sets of features, assess that there is a high degree of matching, and can answer “yes” easily
- In verifying “a penguin is a bird” there is less overlap and it will take longer
- In verifying negatively “a pig is a bird” there is little overlap and we can reject quickly

Semantic Features

- An improved version will include probabilistic weights on features, so not all features are necessarily treated equally
- Features are weighted according to (a) salience and (b) category-truth probability
- “snakes have no legs” is a highly salient feature
- To do a verification task, activation according to these features just needs to pass a threshold
  - Category membership is fuzzy, not all-or-nothing

Semantic Features

- Difficulty: how can we know/list all of the features of a word?
  - Think of the example *game*
  - What would be the semantic features of *game*?
- Do these theories have any room for connotations?

Is a robin a bird?

Is a bird a robin?

- If it's just comparing overlapping features, those two should yield the same answer with the same response time (they don't)

Semantic Features

- In general, these theories seem to be overly reliant on sentence verification tasks
  - Strategies in these tasks can differ from person to person
  - Category membership is not all-or-nothing
    - More of a continuum e.g., *cup* and *bowl*
  - Category membership is not universally agreed upon
    - Is *stroke* a disease?
    - Is *pumpkin* a fruit?
    - Is *virus* a living thing?
- What about non-linguistic features?

Semantic Features

- From an information processing perspective, there’s evidence that features are not accessed automatically
  - Problem for the decompositional account
- Notoriously difficult to test
- Maybe features do exist, but they might be dynamic and non-obligatory
  - So children may rely more on classic primitive features but this system changes over time

Resemblence

- Something like a **prototype theory** lends itself very well to the fuzziness of categories
- Every category has a prototype at the center; category membership is a function of how close to that prototype any item is

robin → bird

penguin → bird

- Like a checklist approach: bird has many characteristic features
  - Robin shares all of these features, so robin is very close to the prototypical bird
  - Penguin doesn’t share all of these features, so it’s not the prototypical bird but it’s still a bird

Resemblence

- Prototype-resemblance should (and indeed does) affect
  - Verification response times
  - Categorization tasks
  - Substitutions
  - Word acquisition order
  - Free recall time

Resemblence

- Again, similar issues
- Not all concepts have prototypes
  - What is the prototype of *truth*
- Items are in the same category because they are similar to each other
- And items are similar to each other because they are in the same category

Resemblence

- Another version is an **instance theory**
- Instead of category representations being abstract, every category has a specific instance
- For the category *dog*, for example, you would have one particular exemplar of *dog* that you've encountered before
    - Or a range of exemplars of dogs
        - More instances → more evidence → stronger predictions
- (still kind of the same issues – what's someone's exemplar for *truth*?)

Connectionist theories

- Connectionist theories are a bit more abstract in that they don’t care quite as much about what the representation is of, rather how it emerges from a system
- Our semantic knowledge may be made up of a network of interconnected microfeatures, which don’t necessarily neatly correlate with features like “has wings” or “cold blooded”
- Each feature could be a low-level semantic representation or even something without a direct linguistic representation
- Similar words will have similar patterns of activation in the network

Latent Semantic Analysis

- Latent Semantic Analysis (LSA) emphasizes co-occurrence information in our ability to set up these networks
  - set up networks = acquisition of meaning
- Context teaches us all we need to know about words and their meanings
- Constraints and co-occurrences will give us synonyms, related and associated words, etc.
- LSA models can simulate human-like vocabulary learning
- Especially useful in cases in which there's no physically-apparent referent

Grounding

- We do need some way to link our meaning system to the real world
- Easy solution for the connectionist models is to link all kinds of input together in the network, including non-linguistic perceptual features
- Semantic system can link across modalities:
    - perceptual features, functional features, encyclopedic features, etc.
    - visual features, olfactory features, tactile features, etc.

- No need to define the features from the start, they will simply emerge from the dynamics of the system
    - So they'll inherently be non-arbitrary and useful

Situated Cognition

- Connecting meanings to perception and action relates to a theory in cognitive science called **situated cognition**
  - The main premise is that cognition is not just the internal mechanisms that turn input to output but that perception, action, and the environment are all part of cognition as well

- People can respond faster to *knife* and *pen* if their hands are positioned like they would be when using those objects (Klatzky et al. 1989)
  - Same with simulating an action
- Priming between *typewriter* and *piano*
- People with Parkinson’s show less priming for action words