Semantic Memory: Rules of the Game

Naveen Kashyap, PhD
Indian Institute of Technology Guwahati
Email: naveen.kashyap@iitg.ernet.in

People hold on to information years after storing them

These contains knowledge relating to *definitions of words, arithmetic facts and procedures, historical, scientific and geographical knowledge to name a few*

The organization of the knowledge follows the metaphor of a book shelf

Information in memory consists of knowledge for specific events and *memory for general knowledge*

Endel Tulving (1972, 1983) argued that LTM contains two stores namely episodic and semantic which although are distinct but highly interactive.

Episodic – Semantic distinction

Episodic – enables people to *travel back in time* and become consciously aware of witnessing or participating in events in earlier time

Semantic – contains general and world knowledge, arithmetic rules, past tense of verbs etc

Episodic	Semantic
Personal Experience	Facts and Concepts
Remember “When”…	Remember “What”….
Temporally Organized	Meaning related Organization

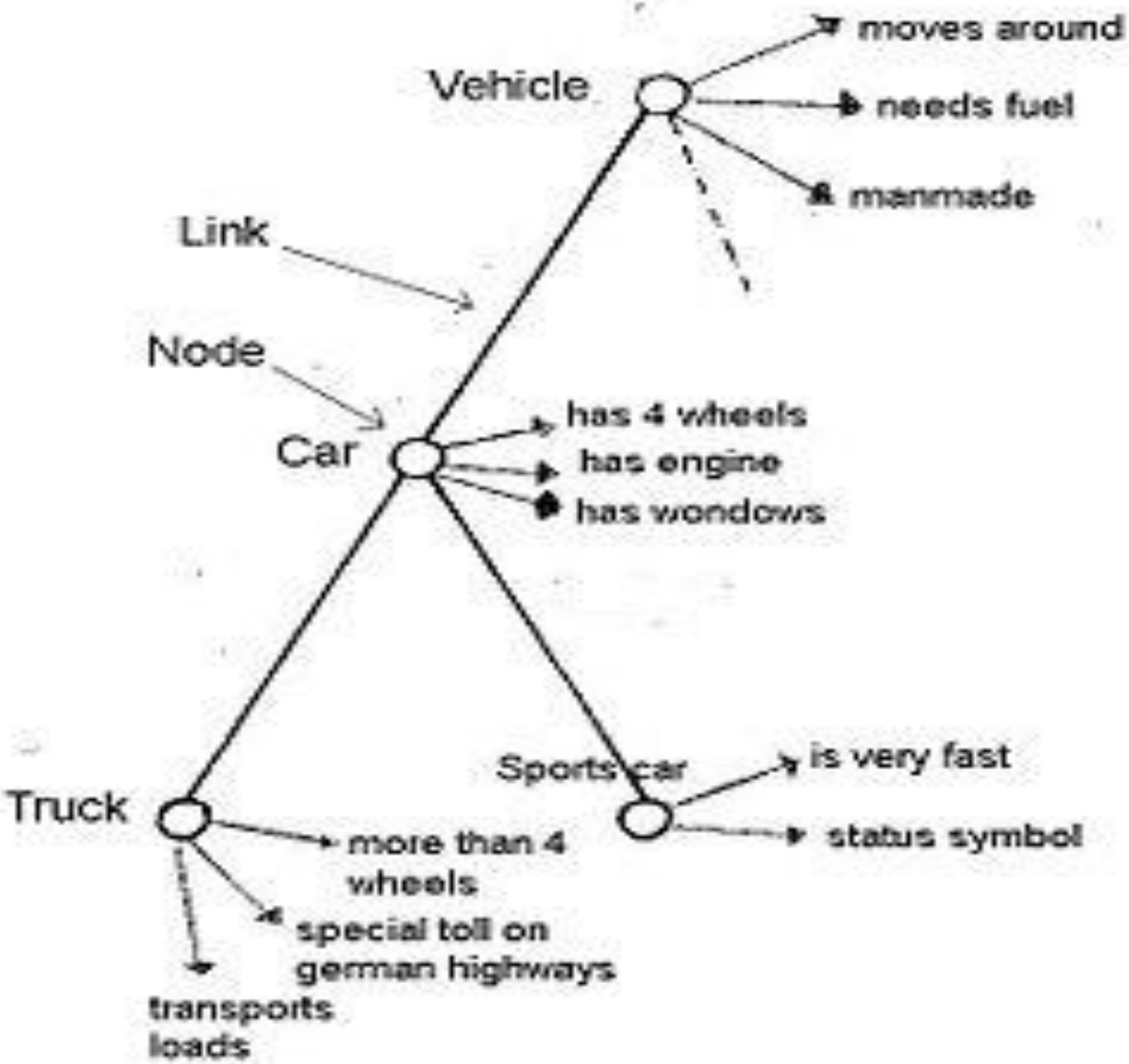
Semantic memory models

The Hierarchical Semantic Model

The model was proposed by ***Collins & Quillinan (1969).*** They tested the idea that semantic memory is analogous to a ***network of connected ideas.***

The Model consists of ***nodes*** (in this case words/concepts). Each node is ***connected to related nodes*** by means of ***pointers***.

Thus the ***node*** *that* ***corresponds to a given word/concept*** *together* ***with*** *the* ***pointers to other nodes*** *to which the* ***first node is connected****, constitutes the* ***semantic memory*** *for that* ***word/concept****. The* ***collection of nodes*** *associated with all the words & concepts is called* ***Semantic Network***


Vehicle
moves around
needs fuel
manmade
Link
Node
Car
has 4 wheels
has engine
has wondows
Truck
Sports car
is very fast
status symbol
more than 4 wheels
special toll on german highways
transports loads

Collins & Quillian (1969) tested the principle of cognitive economy with their model of semantic memory. They reasoned that the closer a fact is stored to a particular node, the less time it should take to verify the fact and property.

T*hey reported that people took* ***less time to respond*** *to sentences whose* ***representations should span two levels*** *(**A canary is a bird**) than for those whose* ***representation should span three*** *(**A canary is an animal**)*

This model was called the ***hierarchical semantic network model of semantic memory.*** The nodes in this model are ***organized in hierarchy*** and most nodes have ***super ordinate and subordinate nodes***. Super ordinate nodes correspond to the category name for which the thing corresponds to the subordinate node was a member.

Meyer & Schvaneveldt (1971) reasoned that ***if related words*** are ***stored close*** by one another and are ***connected to one another*** in a semantic network, then *when ever one node is activated* or energized, ***energy spreads to the related nodes***. One reason for such a fact could be the concept of ***spreading activation***, the idea that ***excitation spreads along the connection of nodes in a semantic network***

Limitations of HMSM

1) *Cognitive Economy*: Conrad (1972) found that people respond no faster to sentences such as “A shark can move” than to “A fish can move” or “An animal can move”.

2) *Hierarchical Structure*: Rips, Shoben & Smith (1973) showed participants were faster to verify “A pig is an animal” than to verify “A pig is a mammal” thus violating the hierarchical structure (animal-mammal-pig)

3) *Typicality Effect*: Rips (1973) found that responses to sentences such as “A robin is a bird” were faster than responses to “A turkey is a bird”. In general typical instances of a concept is responded to more quickly than atypical instances.

The Feature Comparison Model

Smith, Shoben & Rips (1974) proposed an alternative to the HMSM called the ***feature comparison model*** of semantic memory.

Assumption: ***The meaning of any word or concept consists of a set of elements called features. Features come in two types***

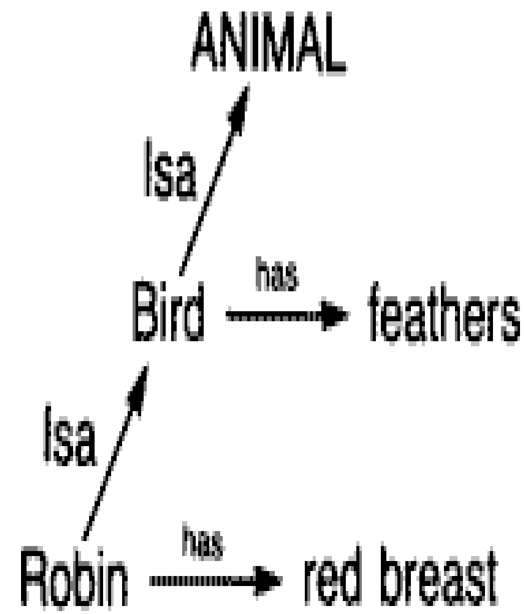
1) ***Defining*** *– meaning that the* ***features must be present*** *in* ***every example*** *of the concept and*

2) ***Characteristic*** *– meaning the* ***features is usually but not necessarily present.***

Attribute or feature list model

Robin	Bird
Physical object	Physical object
Living	Living
Animate	Animate
Feathered	Feathered
Red-breasted	___
___	___
___	___
___	

Hierarchical network model



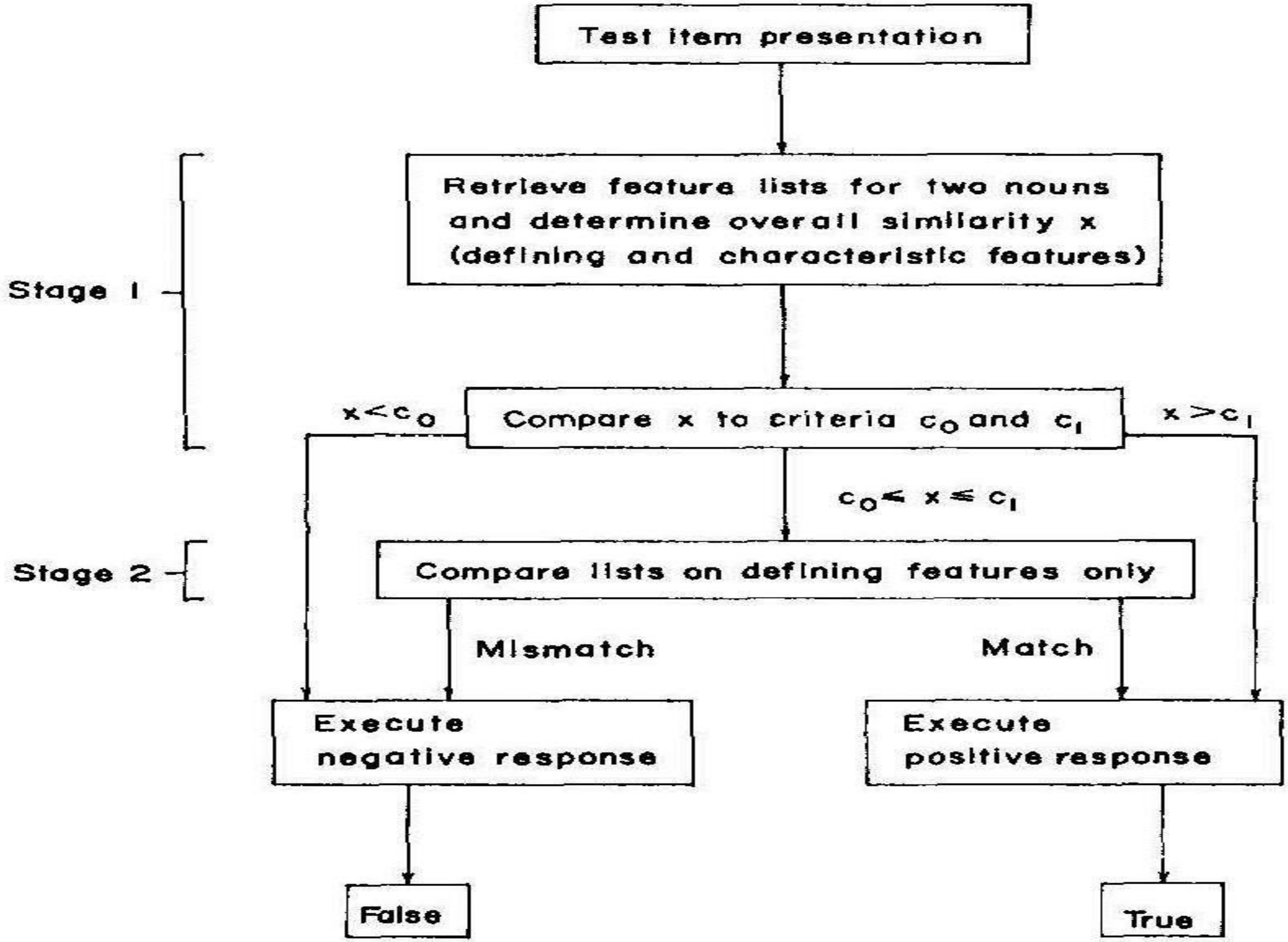


FIGURE 3. A two-stage, feature comparison model for semantic categorization tasks. (See text for explanation.)

Feature Comparison model can explain shortcomings of the HMSM

1) *Typicality Effect*: Sentences like “A robin is a bird” are verified more quickly than “A turkey is a bird” because robin being more typical examples of birds are thought to share more characteristics feature with “bird” than do turkeys

2) *Category Size Effect*: The feature comparison model assumes that as categories grow larger they also become more abstract which lead to lesser defining features.

Criticisms:

1) There is no existence of defining features (suppose a bird has clipped wings. Will it no longer be a bird?)

Other Network Models

Collins & Loftus (1975) presented an elaboration of the Collins & Quillian (1969) Hierarchical model that was the ***spreading activation model***

This model conceives of semantic memory as a ***network, with nodes in the network corresponding to concepts****. They also saw* ***related concepts as connected by paths in the network***

They further asserted that ***when one node is activated*** the ***excitation*** of the node ***spreads down the paths or links*** to related nodes.

They believed that ***as activation spreads*** down the paths or links to related nodes. ***When activation spreads outwards***, it ***decreases in strength***, activating very related concepts a great deal but *activating distantly related nodes* only a little bit.


ANIMAL
P
LEGS
Isa
SPARROW
Isa
FLY
P
P
BIRD
P
WINGS
P
P
BREATHES
WINGS
P
Isa
P
FEATHERS
FEATHERS
P
ROBIN
EYES
P
RED BREAST
P
P
P
P
P
EYES
EARS
EYES
FEET
BREATHES
FEET
Isa
CHICKEN
P
FEATHERS
P
P
EGGS
CLUCKS
P
P
PECKS
ANIMAL

In this model ***very similar concepts*** have ***many connecting links*** and are ***placed close to each other***. Each ***link/connection between two concepts*** is thought to have a certain ***weight or set of weights*** associated with it.

Criticism: The breadth of the model makes it difficult to make clear and strong predictions from the model regarding empirical findings.

Anderson's ACT model

Proposed by ***John Anderson (1976, 83, 93)*** and called the ***adaptive control of thought*** model of memory (ACT, ACT-*, ACT-R). Based on ***analogies to computers***, ACT gives rise to ***several computer simulations*** of cognitive processing of different tasks.

Distinguishes among three types of memory systems:

- Declarative memory (information, facts)
- Working memory (information that is currently at a high level of activation)
- Procedural memory

Declarative Memory

Anderson (1983) believed ***declarative memory stores information in networks that contain nodes***.

There are different types of ***nodes***, including those corresponding to ***spatial images or to abstract propositions***.

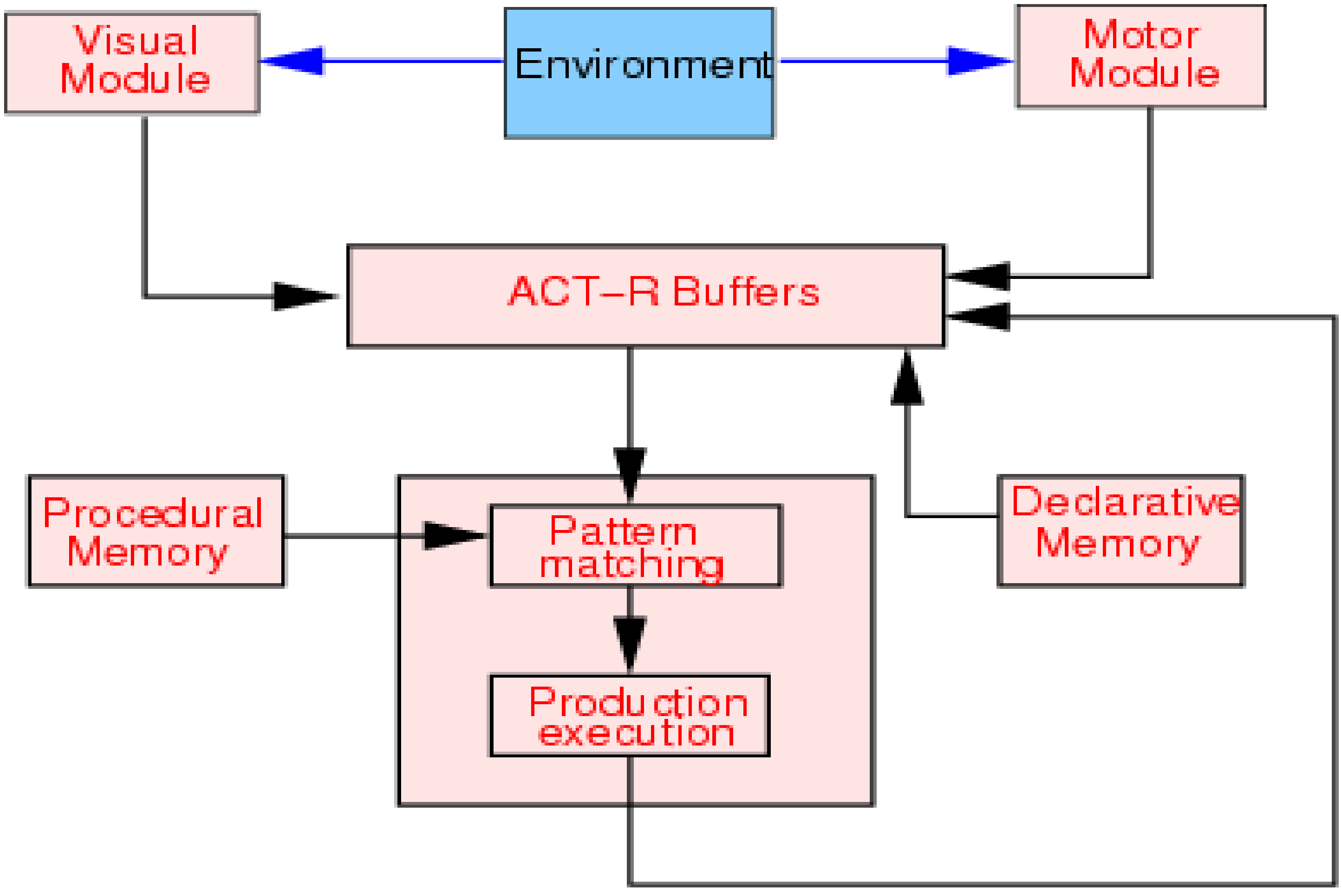
ACT model allows ***both for activation*** of any node and for ***spreading activation*** to connected nodes

Procedural Memory

Representation is as a series of ***"production rules."***

If–then statements that tell ***how to perform*** a particular action

Production rules specify ***a goal to achieve***, one or ***more conditions*** that must be true for the rule to apply, and ***one or more actions*** that result from applying the rule


Visual Module
Environment
Motor Module
ACT−R Buffers
Procedural Memory
Pattern matching
Production execution
Declarative Memory

Connectionist models

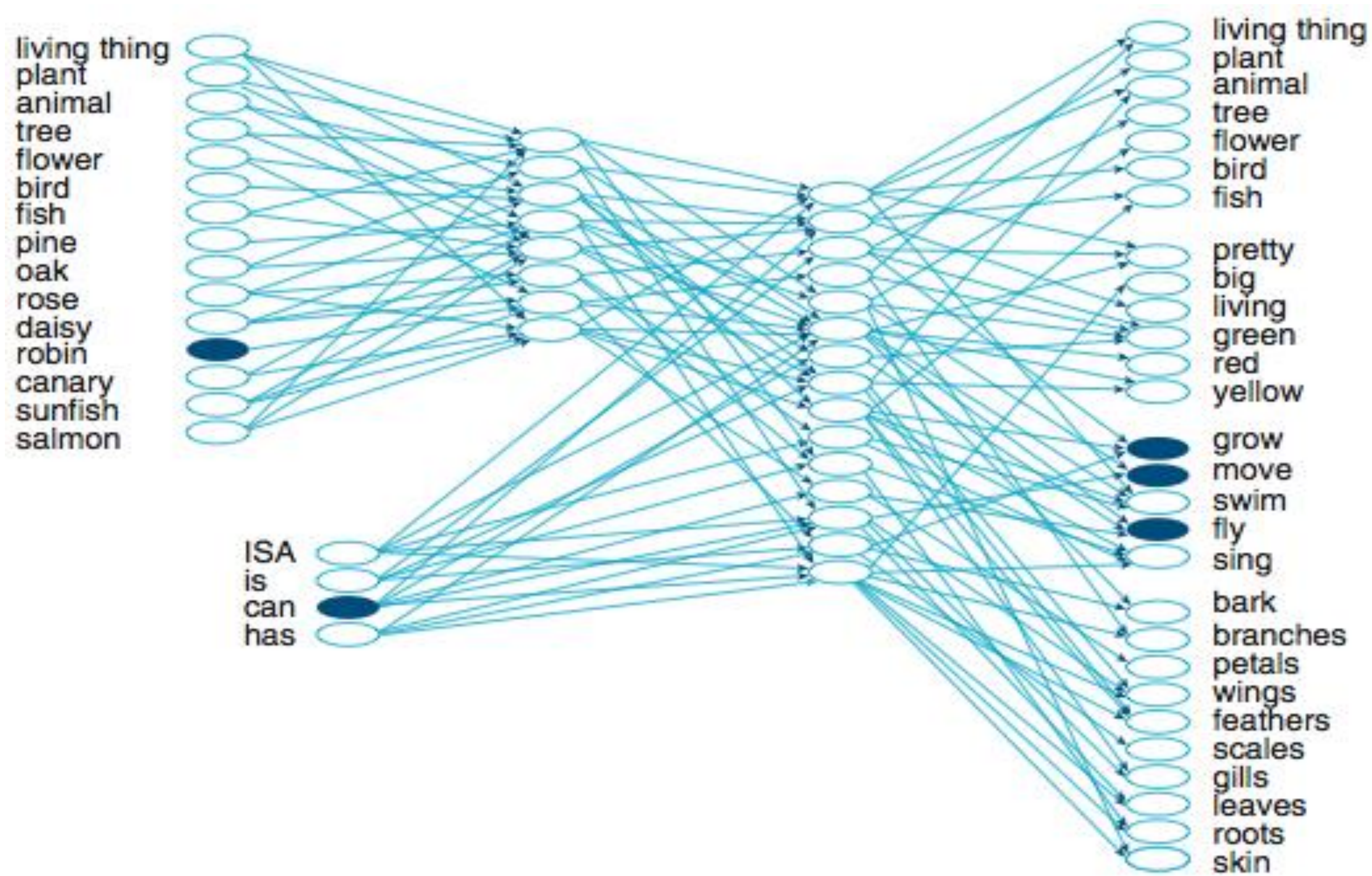
Model ***"learns"*** to develop patterns of activation through ***many trials*** with ***training examples (back propogation)***

Initially, connections between nodes are set at ***random strengths*** (weights); ***experience*** leads these connections to be activated more or less strongly.

Training occurs by presenting a specific example to the network which then generates a particular output.

Training takes places in 'epochs'. Each epoch produces an output activation which is compared with correct target activation.

A connectionist model for “robin”



Schemata

Represents knowledge in Semantic Memory (Bartlett, 1932)

Schemata contains: *General Knowledge about world* *and* *Information about particular events*

Schema – *are* *large units of organized information* *which are used for* *representing concepts, situations, events actions in memory*

Rumelhart and Ortony (1977) – *fundamental building blocks of cognition, units or organized knowledge analogous to theories*

Schemata – *packets of information that contain both variable and fixed part.*

DOG Schemata

Mammal, four legs
(fixed part)

Breed, Size, Color, Temperament
(variable part)

Schemata – *indicated relationship among various pieces of information*

Schemata – *connected to other schemata in a variety of ways*

Schemata – *fills in default values of certain aspects of the situations which help us in making assumptions*

Schemata – *exists at all levels of abstraction; thus they can exist for small parts of knowledge and for very large parts*

Scripts – are schema for routine events (for example going to a restaurant)

Scripts – are used across variety of situations for figuring out unknowns (new city visit)

Scripts – *help us make a number of inferences*

Scripts – *help us for order.*

Bower, Black and Turner (1979) showed that when information from a story is presented in jumbled up sequences people tended to recall the story in scripted order.