Cognitive Psychology

PSYC230

Lecture # 12

Last time

Knowledge Representation

How is information stored in the mind?

What is the "unit of thought"?

A word?

An image?

A logical proposition?

What can memory research tell us?

Different kinds of memories

Procedural LTM scripts & frames	**Declarative LTM**
	Episodic / **Semantic**
"How to" knowledge, implicit memory	Knowledge of what was & what is

Declarative Semantic Memory *(Knowledge?)*

Separate storage from procedural
separate from episodic as well?

Explicit memories, retrieved consciously

Generalised information, not as
context dependent as episodic

Theories of Semantic Memory Representation

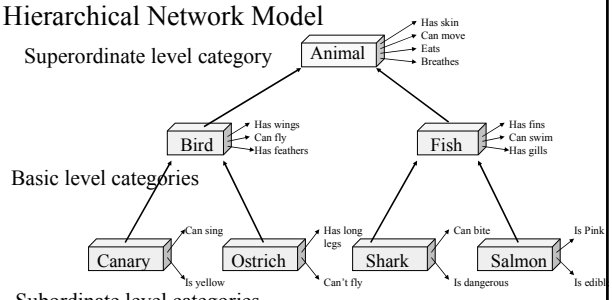
Hierarchical Network Theory
(semantic network model)

Prototype Theory

Exemplar Theory

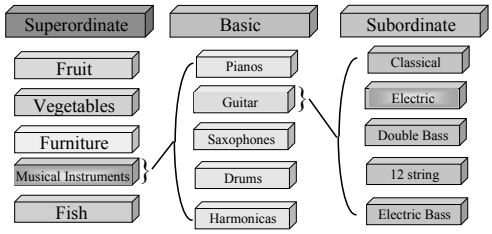
Feature Comparison Theory

Collins and Quillian's
Hierarchical Network Model



Principles of
Property Inheritance
Cognitive economy
Intersection search

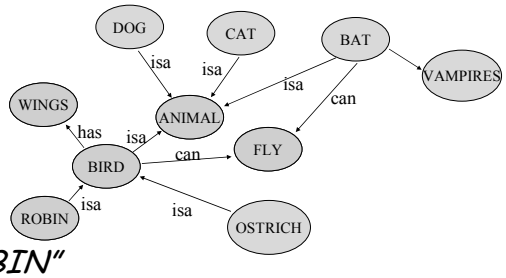
Problems:
Typicality Effect
frequency & redundancy
effects



The Typicality Effect: Good examples of categories are confirmed as members more quickly than atypical members

Semantic Network Models

dropped hierarchical structure
no strict cognitive economy
typical members & properties stored more closely
search via spreading activation



"ROBIN"

Prototype Theory

Focus on Characteristic Features
instead of Defining Features
Compare instances to a "prototype" that best represents the members of that category
(prototype formed through abstraction)

Exemplar Theory

Instead of comparing to a single prototype
we compare to multiple exemplars
Still determined by similarity to characteristic features,
but abstraction occurs during retrieval instead of encoding

Feature Comparison Theory

Two stage process

Stage 1: global feature comparison
fast decisions when there is a high degree of overlap with characteristic & defining features

A canary is a bird

Stage 2: defining feature comparison
required when there is only moderate overlap
(check defining features only)

An ostrich is a bird

Ostriches have few characteristic bird features
but do have defining features of a bird

Is memory the same as knowledge?

Knowledge = *The convergence of perception, memory, and language*

Imagery theory & (sensory) memory

Category-specific perception

Language & naming

Imagery Theory & Memory

How are the units of knowledge stored & represented?

Me: "What is the largest land mammal?"
You: "An elephant"

Does that mean you "thought" the word?

Or, did you think of the image,
and the word came to mind

Although we may answer a question with words, it doesn't mean that we have stored the information in verbal form

Imagery Theory

Images contain *analogue* information

& spatial relations: colour, size, sound

Images occur in the a*bsence of sensory input*

Verbal Codes

Words are symbolic

There is an *arbitrary* relationship between the form of a word and its meaning

Words can refer to *abstract* information

The use of words relies on *rules* (syntax)

Dual-code hypothesis

Both *Imaginal* and *Verbal codes* are used
Some information is exclusively *imaginal*
Some is exclusively *verbal* (abstract words)
Concrete words are represented in both codes

What is the role of Imagery in knowledge representation?

Is Imagery a form of representation used in processing?
or
Is Imagery an *epiphenomenon* (a by-product) of processing?

Propositional Theory
the challenger to Imagery Theory

Propositions are abstract, non-linguistic, "mentalese" that express a relationship between concepts

e.g., verb (subject, object)

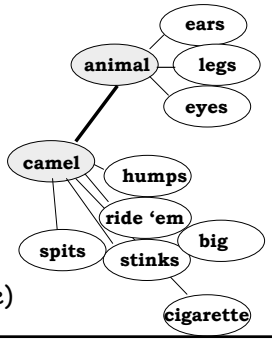
teaches (Sam, psychology)

adjective (noun)

interesting (course)

Propositional Theory argues that we store facts about concepts, including the relative size of objects and animals

is a (camel, animal)
has (camel, humps)
can (camel, ride)
is (camel, big)
does (camel, spit)
smells (camel, bad)
is a (camel, cigarette)



Propositions convey meaning relations, not linguistic form
(propositions are not verbal codes)

"*The pony kicked the cat*"
kick (pony, cat)

is represented in exactly the same way as

"*The cat was kicked by the pony*"

kick (pony, cat)

Different "surface structure"
same "deep structure"

Pictures and words can both be represented propositionally

*
\+

"*The star is above the plus*"

above (star, plus)

above (star, plus)

Who's right, Imagery Theory or Propositional Theory?

If Imagery Theory is right, you would expect *functional equivalences* between visual images and percepts of physical objects

Images can be moved and transformed
Mental rotation studies (Shepard)

Bigger images take longer to construct
close your eyes – form a mental picture of this room
close your eyes – form a mental picture of the campus

Images can be scanned (Kosslyn)

Long distances on images of maps take longer to scan
Images can be scanned at different levels of detail

Neural evidence for imagery
(Kosslyn, 2001)

Motor imagery

Participants visualised object rotation, either by internal action (by hand) or external action (motor driven)

When Pet scans are compared, difference is in Motor cortex – images can contain motor movements

Auditory imagery

Participants listened to music, or imagined music

Pet scans show striking similarities between listening and imagining music

Neural evidence for imagery
(Farah)

Event-related potential (ERP) in normal participants

house
cat
ball
car
tree
book

Group 1. Read this list of words

Group 2. Read each word and imagine what it looks like

Reading + imagery condition resulted in increased activity in the occipital lobe (visual cortex) relative to *reading alone*

What kind of evidence would you look for to support Propositional Theory?

Evidence that propositional, rather than surface, information is stored in memory

We remember meaning, not form
(Sachs)

Relations between underlying propositions, (not those between sentences) determine our memories of discourse (McKoon & Ratcliff)

Who's right, Imagery Theory or Propositional Theory?

(Better question: which situations favour use of imagery rather than propositions?)

Name this animal and tell me what you know about it

The Symbolic Distance Effect

Imagery Theory argues that we use mental images to compare the relative size of concepts that are expressed as concrete nouns

"Which is larger?"

lion or horse?

mouse or horse?

Imagery Theory predicts mouse/horse will be faster, because the mental images of mice and horses are so much different in size

Propositional Theory predicts that the relative size of animals will make no difference in the speed of answering "*which is larger?*"

mouse	will be the same as	lion
horse		horse

But, Propositional Theory does predict a Congruity Effect asking "*which is larger?*" about two small animals will take longer because "largeness" isn't one of the facts we have stored about small animals and is an incongruent question

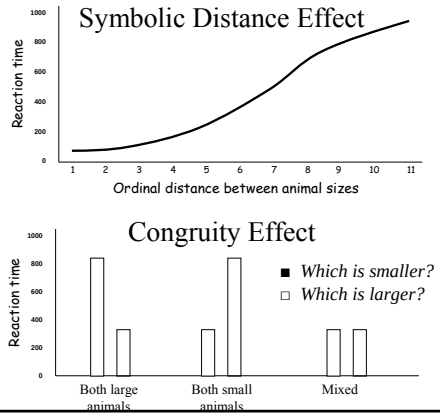
Symbolic Distance Effect: Examples

Six small animals: fly, mouse, frog, ferret, cat, dog

Six large animals: sheep, lion, horse, hippo, elephant, whale

Distance = 1	Small pair: mouse, frog Large pair: lion, horse Mixed pair: dog, sheep
Distance = 4	Large pair: sheep, elephant Small pair: mouse, dog Mixed pair: ferret, horse
Distance = 11	Mixed pair: fly, whale

Researchers routinely find evidence for both



Category-specific Perceptions

Category Deficits

Some brain lesions result in patients unable to recognise or name artifactual (man-made) things, such as tools & utensils

They can still name and recognise living things, like animals, fruits & vegetables
(or vice versa)

What does this tell us about representation & organisation of knowledge?

Category Deficits

Patient VER: cannot name tools, furniture etc., but can name animals

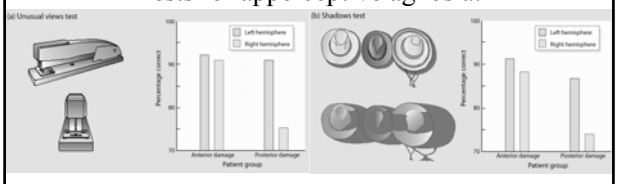
Patient CH: impairment for furniture & body parts no impairment for animals

Patient YOT: cannot recognise manipulable items (things that can be grasped & moved) or body parts, but can recognise animals, vegetables, and food

Perception & recognition deficits can be separated

Apperceptive Agnosia: impairment in perceptual processing, prevents recognition – right hemisphere

Tests for apperceptive agnosia:



Do the two pictures show the same object seen from two different perspectives?

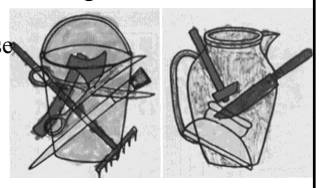
Most problems when objects are seen under atypical conditions (e.g., perspective or illumination).

Perception & recognition deficits can be separated

Associative Agnosia: failure in object recognition NOT due to problems in perceptual processing
(associative agnosia is left hemisphere)

Tests for associative agnosia:

Patient FRA: cannot recognise (name) the objects but can colour them in separately (perceptual skill intact)



Patients with apperceptive agnosia could not colour the items separately

Is recognition the same as naming?

Naming deficits and recognition deficits look quite different in bran scans

Associative Agnosia: failure in object recognition NOT due to problems in perceptual processing (left hemisphere)

Perception & recognition deficits can be separated

Tests for associative agnosia:

Matching by function task

Does this mean Gall was correct, similar types of knowledge are all globbed together?

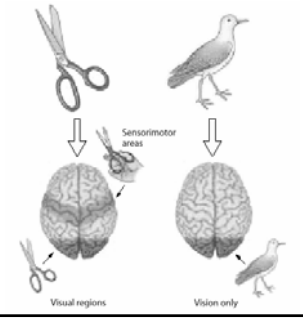
Localisation of function in the nervous system

Possible reasons for category specific agnosia

Recognition of living things may be more difficult in some cases because there is living things are more similar to one another than non-living things

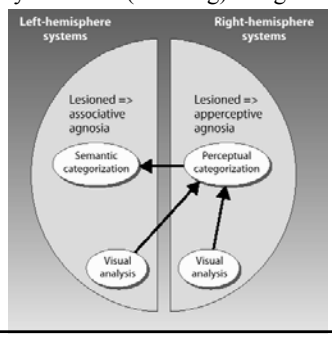
Possible reasons for category specific agnosia

Some commonly used objects will have sensori-motor representations as well as visual representations



Possible reasons for category specific agnosia

Warrington's two-stage model:
initial categorisation occurs perceptually, followed by semantic (meaning) categories



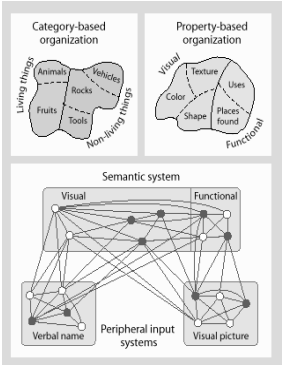
Why do these categories exist and not others?

Why aren't there patients with a category deficit for Hollywood Action Heroes or Fast Food Restaurant chains?

Things belonging to a category share common features -- concepts (or semantic representations) are activated by input features.

Some things belong to multiple categories and have multiple representations and routes of activation

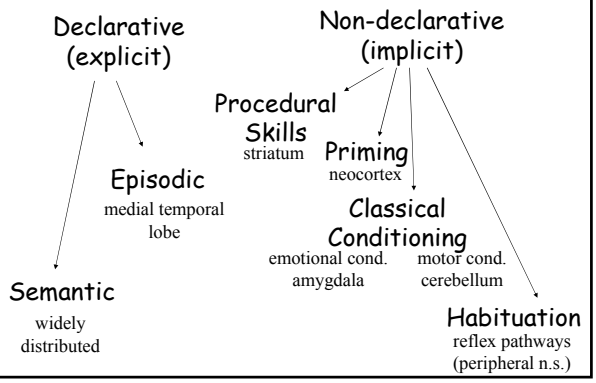
Two different hypothesis concerning the organization of semantic knowledge



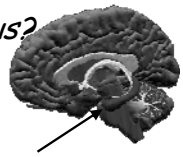
Things may be represented in several ways, depending on our experience with them

Our representations of facts encompass multiple dimensions and are distributed (and linked) accordingly

Taxonomy & Anatomy of Memory



What about the hippocampus? Where does it fit in?



Several views on the hippocampus:

Explicit memory is an example of the kind of memory the hippocampus processes

The hippocampus is only involved in explicit memory

The hippocampus is specialized for spatial memory and was co-opted for explicit memory when language developed

Now that we have an idea what knowledge is and how it is stored, can we build it?

Artificial Intelligence (AI)

If we can we build AI models will that tell us how human knowledge works?

Connectionist/PDP Models

Parallel Distributed Processing (PDP)
Rummelhart & McClelland (1986)

a *distributed representation* of declarative knowledge

PDP models use ***neural networks*** where information is distributed across multiple layers, and processed in parallel, roughly similar to living organisms

"Neurons" can be in one of 3 states

Inactive

Excitatory

Inhibitory

Activation strengthens or weakens connections between neurons/units

Knowledge is represented in the pattern of activation across the network

Connectionist models are very powerful and popular models in cognitive psychology & cognitive science

Four properties of PDP models:

content addressable memory

graceful degradation

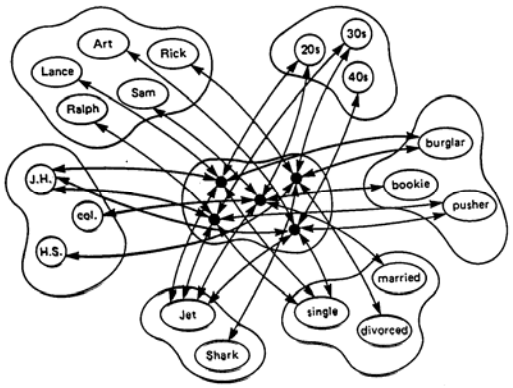
default assignment

generalisation

Table 5.1
The Jets and the Sharks

Name	Gang	Age	Education	Marital status	Occupation
Art	Jets	40s	J.H.	sing.	pusher
Al	Jets	30s	J.H.	mar.	burglar
Sam	Jets	20s	col.	sing.	bookie
Clyde	Jets	40s	J.H.	sing.	bookie
Mike	Jets	30s	J.H.	sing.	bookie
Jim	Jets	20s	J.H.	div.	burglar
Greg	Jets	20s	H.S.	mar.	pusher
John	Jets	20s	J.H.	mar.	burglar
Doug	Jets	30s	H.S.	sing.	bookie
Lance	Jets	20s	J.H.	mar.	burglar
George	Jets	20s	J.H.	div.	burglar
Pete	Jets	20s	H.S.	sing.	bookie
Fred	Jets	20s	H.S.	sing.	pusher
Gene	Jets	20s	col.	sing.	pusher
Ralph	Jets	30s	J.H.	sing.	pusher
Phil	Sharks	30s	col.	mar.	pusher
Ike	Sharks	30s	J.H.	sing.	bookie
Nick	Sharks	30s	H.S.	sing.	pusher
Don	Sharks	30s	col.	mar.	burglar
Ned	Sharks	30s	col.	mar.	bookie
Karl	Sharks	40s	H.S.	mar.	bookie
Ken	Sharks	20s	H.S.	sing.	burglar
Earl	Sharks	40s	H.S.	mar.	burglar
Rick	Sharks	30s	H.S.	div.	burglar
Ol	Sharks	30s	col.	mar.	pusher
Neal	Sharks	30s	H.S.	sing.	bookie
Dave	Sharks	30s	H.S.	div.	pusher

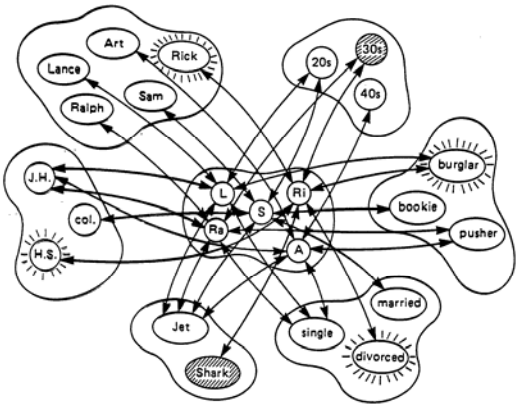
Source: McClelland, Rumelhart, and Hinton 1986, p. 27, fig. 10.



Content addressable memory

information is accessible
through multiple routes
even with only a partial description

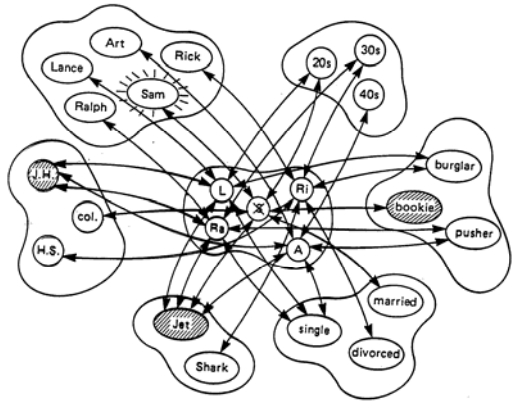
Who is a Shark in their 30s?



Graceful degradation

PDP systems are error-tolerant,
information can still be found
even with damage to part of
the system or partially incorrect
information

Who is a Jet, a bookie, married, & has a junior high school education?



Default assignment

ability to make assumptions where there are no data available

Is Lance a burglar?

most JH educated Jets in their 20 are, thus "burglar will be activated for Lance (instead of pusher or junkie)

Generalisation:

PDP networks can generate typical sets of properties, i.e., generalisations

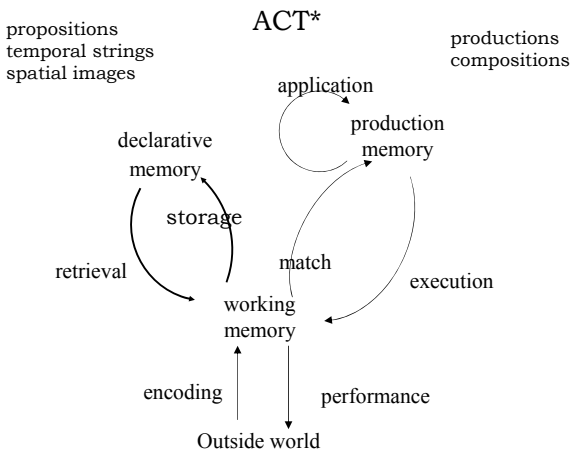
Activate just the item "Jet" the network will produce a profile of the typical Jet: single, 20s, JH education

even though no single individual typifies that pattern

Connectionist/PDP models mirror many human memory processes (graceful degradation, default assignment, generalisation) and simulate existing data on verb learning (McClelland & Rumelhart, 1986) & speech production (Dell, 1986)

ACT* -- Adaptive Control of Thought
John Anderson (1976, 83, 90, 99)

model based on a production system tries to represent a general approach to all types of information and tasks



ACT* incorporates a variety of empirical findings including semantic priming, typicality, paired-associate learning, encoding specificity, and others

ACT* has been used as the foundation for several AI tutoring systems

It has not, however, received anywhere near the attention and popularity of the PDP approach

Next Time:

Knowledge Extraction & Expert systems

Decision making