

# Meaning-based Interpretation, Schemas, and Categorization

Psy 20  
Prof. Camerer  
Ch 5 Anderson

Perception-based representations have no special role for meaning (i.e., meaningfulness does not enhance/inhibit perception).

But meaning matters:

Ideas seem to be stored as gist-extractions represented as  
"propositional networks"  
(like marked bones which can be "reassembled" into skeletons)

or schemas, scripts...

## Meaningful interpretations

People remember sentences by meaning  
(evidence: misremember "wrong" sentences w/ similar meaning).  
i.e., they are storing the gist, rather than the precise sentence  
(like a story synopsis rather than the whole book)

Same with pictures (Figs 5.2-5.3).  
E.g. picture w/ teacher is misrecalled if meaningless detail is changed  
(dress color) but not if meaningful detail changes (map/art)

Detail vs meaning:  
missionary-painter example

(trick-- creating meaning--> better memory mnemonic tricks)

How is meaning represented?

one answer: Propositional networks

relations are predicates taking arguments as values

e.g. the game Clue    kill[person, room, weapon]

Figs 5.5-5.6

can explain memory for (propositional-representable) gist

How do we know info is stored in these networks?

Sentences which are consistent with represented info are

misremembered as having been present in original text

i.e. prop'l nets do not reliably "back translate" into original  
text, but can be used to create gist-equivalent text

Is there any structure to relations?

Schank: List of 12-15 primitive actions (Table 11.1)

[exhaustive list?-- nah, to think so is engineering/AI fetish?]

Evidence: Complex sentences (poorly-connected)

harder to recall than well-connected ones

(Ida sold/mailed tenants a clock)

Problems: Primitives are like "characteristic attributes" in categorization.

Need a lot of modification for "special cases"

...too many special cases undermines claim to compact universality

e.g., `the play moved Ingrid' not the same as

`the moving company moved Ingrid'

`lie' depends on speaker's knowledge, intent to deceive

`murder' depends on what you're wearing (fatigues=war)

## Schemas

Clusters of organized concepts.  
Reflect relations and domain knowledge  
(explanatory links among concepts)

Relations have slots and slot values  
(can be simple/complex, subrelations...)

Can leave slots open (default values)

Evidence for schemas:

Interrater agreement on basic elements (restaurant scripts)  
Expectations influence perception, recall  
(office study Fig 5.9)  
Automatic processing is "mindless" (wrong silverware)

## Refinements (largely computational)

Memory Organization Packets (MOPs)

Clusters of "scenes"  
Hierarchically organized (goals at top, sets of actions,...)

Thematic Organization Points (TOPs)  
similar scene-clusters

Action picture TOP:

Hero/hero's friend victimized  
Villain motivated by evil (greed, jealousy..)  
Friend cannot fight back (perhaps dead)  
Hero goes on arduous journey  
Falls in love (at long last)--  
    then love interest gets killed/endangered  
Many obstacles-- bureaucracy, moral restraint,  
    real tired  
Kill villain in end.

Evidence for TOP

Priming-- quicker recall of related scenes, TOPs

Problems:

Undisciplined. What isn't consistent w/ them? (nonfalsifiable?)

## **Categorization:**

Explanation-based approaches

Attribute relations

How do we categorize things?

Three desiderata:

- cognitive economy (good to lump things together)
- informativeness (good to separate things)
- naturalness (good for categories to reflect natural co-relation)

### **Defining-attribute view**

Categories are conjunctions of defining attributes

Birds = {feathers, lay eggs, hollow bones,...}

Each attribute is necessary, all are jointly sufficient

- > Categories are clearly-bounded (A)
- All members are equally "typical" (B)
- Subordinate categories (professors) inherit all properties of superordinate categories (humans) (C)

Evidence for defining-attribute view:

Apparent def'-attribute strategies in Bruner (1956)

against: Faster verification of some attributes

All-equally-representative property B false

--> `best' examples verified faster

deeper problems: Many categories quite fuzzy & unstable  
E.g. what's a game? (war-games, mind games...)  
Are book-ends furniture?  
Is a child a pet?

### **Defining- and characteristic-attribute view**

Categories are conjunctions of defining & characteristic attributes

Defining attributes are core (necessary)  
Characteristic attributes determine typicality

Two-step checking process:

1. Compare all attributes; if inconclusive  
(Penguins are birds?)
2. Compare core attributes

--> Can explain different verification speeds  
(robin fast vs. ostrich slow)

Allows variation in typicality

Allows linguistic hedges,

'Strictly speaking, Madonna is a successful actress'

Problems: What are defining attributes?  
(Do any exist at all?)  
Still predicts clear-cut membership

### **Prototype/exemplar theories**

Prototype is collection of characteristic attributes  
Or closest example of concept

--> Membership fuzzy, unstable  
Members range in typicality  
Typicality depends on similarity to prototype

Evidence: Typical members better remembered, quicker ID'd,  
mentioned first in list-making, cognitive referent  
(MIT is the Caltech of the east, not vice versa)

Family resemblance scores correlate w/ typicality

Prototypes and hierarchies:

Evidence for three levels:

Superordinate	Animals	Scientists
Basic	Beasts of burden	Physicists
Specific	Camels	S. Hawking

Basic level has most 'distinctive attributes'  
and most differentiated from other basic categories  
(Cf. Biological notion of genus etc.)

Basic level critical to motor activities (E.g. furniture, speaking)-->  
learned, named first ('privileged')

What's basic depends on expertise, culture, gradations that are needed  
(27 Eskimo words for snow, expert wine adjectives, musicians w/ drums)

Limits of hierarchical prototype view:

Abstract notions have no strong prototype  
(beauty, war, violence, justice)

Ignores relations between attributes  
(E.g. within-category variation)

Concept instability-- depends on context  
(frogs as noisemakers vs. food; need multiple membership)

Concept mix-and-match undermines strength of membership  
Fake gun is not a good gun, not a good fake  
Pet fish

Prototype may be statistically unusual/exaggerated  
(Einstein is prototypical scientist, but not a good representative  
bundle of features)

### **Similarity to prototypes**

How is similarity judged?

Natural model: Distance in some attribute space.

Wrong! Distance model predicts:

Symmetry  $S(A,B) = S(B,A)$

Violated by (Cuba, Russia) and opposite  
(US, Canada)

Triangle inequality:

$$d(A,B) + d(B,C) \geq d(A,C)$$

But  $d(\text{Cuba, Haiti})$  low,  $d(\text{Cuba, Albania})$  low  
 $d(\text{Haiti, Albania})$  high

Tversky feature model

$$s(A,B) = a f(A \cup B) - b g(A \setminus B) - c h(B \setminus A)$$

Explains higher similarity for  
Cuba (low A feature set)  
vs. Russia (high B feature set)

Can explain asymmetry if parameter  $c > b$

## **Relations**

Are relations among attributes a separate attribute?

E.g., feathers on wing  
(E.g., consistency, or “typical” amount of variation)

E.g., Medin et al (1990) study Fig 10.3

## **Connectionist model**

Separate feature pools, person pools, category pools.

Inhibitory connections between members of each pool  
(Person can only be one thing)

Pass activation around repeatedly until steady state.

Can “see” person features by ‘clamping’

Can “see” category features the same way

Demonstrates feasibility of ‘bottom-up’ category making

# Numerical cognition

Psy 20  
Prof Camerer

Will it ever happen that mathematicians will know enough about the physiology of the brain, and neurophysiologists enough of mathematical discovery, for efficient cooperation to be possible?

-- Jacques Hadamard

Words and language, whether written or spoken, do not seem to play any part in my thought processes. The psychological entities that serve as building blocks for my thought are certain signs or images, more or less clear, that I can reproduce and recombine at will. -- Einstein

I used to love, and still love, mathematics for themselves as a domain that does not admit hypocrisy and vagueness, my two pet aversions--  
Stendhal

$2+2=5$  is a reasonable error-- Wittgenstein

## How are numbers processed in the brain?

Claim: Separate circuits for exact arithmetic (uses left frontal, language) & magnitude estimation (sense of number) along with primitive no. processor (exact  $\leq 4$ ?) in animals, babies

Primitive processor:

“Subitizing” range up to 4 in infants, G’s patients, animals  
(J Allman’s dog “counting” frisbees)

Subitizing adapted to hunting/gathering track of object locations??

## Magnitude estimation

Animals pecking levers & humans “guessing” taps (humming) exhibit “scalar variability”: Variation in number rises with size (Fig 1, Gallistel-Gelman)

## Exact arithmetic

PET study with exact addition (present  $5+4$ , then choose 9 or 3)  
.vs approximate addition (then choose 8 or 6)

Differences in activation \*even during presentation of  $5+4$ \*

Evidence for two systems:

- Patient MAR could not decide if 7 is between 1, 3 but  
Could “bisect” other objects (days of week, letters)
- Dyscalculic patients  
Mr. N lesion in posterior left hemisphere  
Can’t add  $2+2$ , count backwards, etc. (counts on fingers)  
But can approximate! Year=350 days; hr=50 minutes  
Sees 6-7-8 "can’t recall if I saw 5 or 9, but definitely not 1!"
- Bilingual study (trained on  $34+78$  in Russian, slower in English)  
No difference in approx addition, approx’n of logs, cube  
roots
- Patient w/ left premotor cortex damage could \*only\* write  
numbers (Fig 7.4)
- Arithmetic epilepsy:  
A 16-year old school girl (Sri Lanka) had been experienced sudden jerky movements of her right arm...when studying mathematics (!). ...she began to develop jerks about 30 minutes after starting the mathematics paper. The pen dropped out of her hand and she found it difficult to concentrate. (Ramachandran)  
Neurology: Hyperexcitable network in inferior parietal region
- Acalculic patient could not solve  $2 \times 3$ ,  $9/3$ ...but could do algebra like  $(axb)/(bxa)=1$ , or knew  $a+(d/c)=(d+a)/(c+a)$  is false!  
(Specialized algebra knowledge)

- Single neuron measurement of epileptics (Fig 8.7)  
Specialized neurons fire in parietal cortex when Ss add digit strings (1,2,5,3..)

Alternative view (Gallistel-Gelman):

If animals can add, subtract, multiply then arithmetic performance is not geared to language

adding: macaques taught to choose numerals 1-9 corresponding to numbers of peanuts  
could “add” two numerals-- Basket (1,4) vs. (3) they pick (1,4)  
Chimps see 1 in one location, 6 in another, learn to pick “7” in a new location

Subtracting: “violations of expectation” paradigm--  
use gaze time as a measure of when animals suspect an error  
rhesus monkeys surprised by subtraction mistakes  
(E.g., hidden array w/ 4 bars. One disappears, then revealed that there are 2 left..monkeys stare)

Multiplying: Direct neural evidence for multiplicative combination of P(reward) and magnitude (a la expected utility theory!)

Alternative view 2 (Simon):

numerical processing comes from perception/attention/visuospatial  
-- infants in many cultures learn to count with their fingers  
(Brazilian street kids use body parts to “make change”!)

Gerstmann's syndrome (left parietal damage)

Lose ability to tell whether your fingers are being touched

\*and\* inability to process numbers (acalculia)!

(Dehaene: This is used to generate a number line, used for  
approx'n)

Reading: S Dehaene, The Number Sense; Dehaene et al Science 1999;  
Simon, Trends in Cog Neuro 1999; Dehaene & Spelke, Trends in Cog  
Neuro, 1999

## DREAMS

**Psy20**

**Prof. Camerer**

### **Facts about dreams**

Nature of dreams-- bizarre, illogical (flying), often emotional  
(anxious, happy), some senses disabled (smell, taste)

Eye movements reflect what the dream is about

(watching ping-pong, L-R; up stairs, up-down moves)

Rarely remembered ("dream amnesia) unless awakened in the middle

Cats w/ lesion in portion of brain that controls "sleep paralysis" "act  
out" their dreams

Babies dream a lot 8 hrs vs 1-2 adults (even more in womb, 6-9 mos)

Only mammals w/ no REM are spiny anteaters, w/ jumbo cortexes

REM-sleep deprivation--> catchup next night+ waking hallucination?

(need regular amount of dreaming)

Students who are cramming for exams dream more!

Post-REM people are "hyperassociative"-- weak primes stronger than  
strong primes (thief-wrong vs. hot-cold)

### **Theories of dreams**

### **Freud (psychoanalytic):**

Dreams reveal repressed wishes or urges, triggered or associated with a recent experience ("day residue") but disguised (hence, bizarre)  
What about babies? Etc.

### **Hobson**

Activation synthesis

Brain generates internal "activation". Attempts to make sense but cut off from usual tools (logic, motor skill checking)

But what biological purpose could this serve?

Keeps the motor running? (Like machinery that's expensive to start up again)

**Crick/Mitchison:** Dreams reflect "unlearning"

Neural nets have 'parasitic modes' from overload

I.e., nets too small relative to possible patterns, and similarities  
(statistical overfitting)

obsession (give same output for all inputs)

fantasy (wierd assoc'ns, overgeneralize from input)

hallucination (self-activated, respond inappropriately)

Parasitic modes are a byproduct of not "prewiring" (w/ genes) too much information into the networks-- want them to learn from experience

Theory:

Dreams are "unlearning" that squashes 'parasitic modes' w/ random inputs.

...result is weird patterns of activations.

Brainstem stimulates w/ PGO waves, produces REM + dreams

Body heals faster during sleep (skin/nail growth)

...maybe dreaming is like "healing" neural nets

Consistent with:

ant eater (has bigger network, doesn't need unlearning)

babies

students, sleep deprivation catchup

dream amnesia (don't need or want to remember them;  
aminergic neurotransmitters used for learning are "turned  
off" in sleep)

hyperassociativity?? Maybe...

May be related to schizophrenia (e.g. breakdown of unlearning  
"causes" schizophrenia)?

Difficulties for the unlearning account:

Recurrent dreams?

Those awaken you (anxiety) so

they are remembered & hence recur?

Some drugs (MAO inhibitors) reduce REM sleep w/ no  
apparent behavioral deficits

No hope for analysis of dream content?