Perceiving Function and Category

Ish Rishabh and Vivek Singh

CS213: Visual Perception

Professor Aditi Majumder

Perceiving Function and Category

- Visually perceive
- Functionality of objects that we see
- Categorization: Classify into known types

Agenda

- Part 1: Perception of function
- Part 2: Categorization: Various phenomena
- Part 3: Theories of Categorization
- Part 4: Recognizing letters and words

Perception of function

Perception of Function

Direct → Affordances

Indirect → Categorization

Flat surface
Horizontal
Strong
= Sittable

J. J. Gibson

Sittable

All others

Direct Perception of Function

- Traditional approach was *categorization*
- Gestalt psychologists argued direct perception
- *Affordances:* properties that prompt user interaction
- J. J. Gibson (1979) claimed that:
  - Objects can be *grasped upon*, *sat upon*
  - No standard categories for such affordances

Affordances

- Two important considerations:
  1. *Functional form:* Function must follow from form
     - Round wheels: rolling
     - Triangular wheel?
  2. *Observer relativity:* Affordances perceived depends upon the observer.

PART 1
➢Perception Phenomena
➢ Direct Perception
Indirect perception
PART 2
Categorization
PART 3
Theories of Categorization
PART 4
Recognizing letter & word

Affordances (continued)

- Neisser (1989)
- Functional properties that conform to both conditions are called ***physical affordances***
- These are *necessary*, but *not sufficient* for direct perception (Gibson)

Send Letters

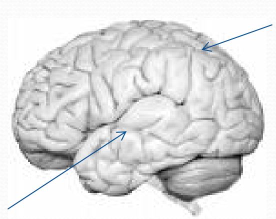
Similar affordances

Different perceptions

Dumb garbage

Affordances (continued)

- Neisser suggested:
  - Affordances and categorization are fundamentally different *modes* of perception
  - Accomplished by *different* neural systems
- Evident in patient with damaged ventral system



PART 1
➢Perception Phenomena
➢ Direct Perception
Indirect perception

PART 2
Categorization

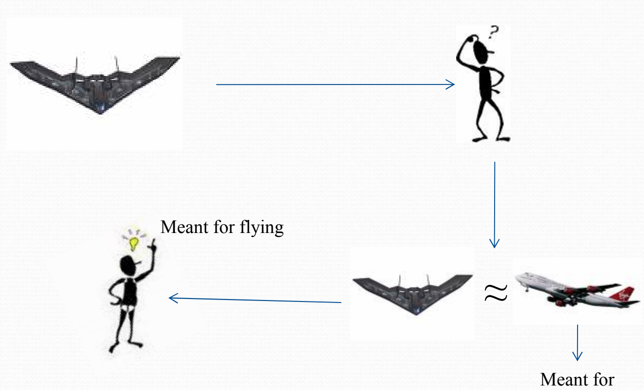
PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Affordances (shortcomings)

- Cannot account for all functional information that we perceive
  - Example: CDs
- Hence categorization approach is important

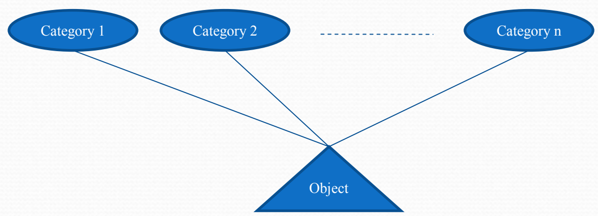
Indirect Perception of Function by Categorization



Boils down to categorizing *object*

Categorization: Four Components

1. Object representation
2. Category representation
3. Comparison processes
4. Decision processes



Categorization: 1. Object representation

- Shape is the most important
  - Templates
  - Fourier spectra
  - Feature lists
  - Structural descriptions
- Other information
  - Texture
  - Color
  - Size
  - Orientation

Categorization:
2. Category representation

- Shape is the most important
  - Templates
  - Fourier spectra
  - Feature lists
  - Structural descriptions
- Other information
  - Texture
  - Color
  - Size
  - Orientation

Categorization:
3. Comparison processes

- Object and category *representations* should be of the same *type*
- Comparison: Serial or parallel?
  - Comparing *across categories*: parallel
    - Very large number of known categories
  - Comparing elements *within representation*: Not obvious.

Categorization:
4. Decision processes

- Which category does the object belong to?
- Should support:
  1. Novelty
  2. Uniqueness
     - For mutually exclusive classes
     - A thing cannot simultaneously be *cat* and *dog*
- Get *fit value* for each category
- Three *approaches* of decision making:
  - Threshold rule
  - Maximum (best-fit) rule
  - Maximum-over-threshold rule
    - Most appropriate

PART 1
➢Perception Phenomena
Direct Perception
➢ Indirect perception
Object representation
Category representation
Comparison processes
> Decision processes

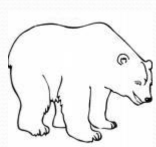
PART 2
Categorization

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Categorization:
4. Decision processes (cont.)

Problem with threshold: Not unique

PART 1
➢Perception Phenomena
Direct Perception
➢ Indirect perception
Object representation
Category representation
Comparison processes
> Decision processes

PART 2
Categorization

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

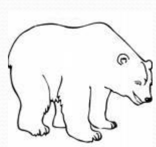
Categorization: 4. Decision processes (cont.)

Problem with best fit: No novelty




Categorization: 4. Decision processes (cont.)

Maximum over threshold: Preserves uniqueness

Categorization: 4. Decision processes (cont.)

Maximum over threshold: Preserves novelty

PART 1
➢Perception Phenomena
Direct Perception
➢ Indirect perception
Object representation
Category representation
Comparison processes
> Decision processes

PART 2
Categorization

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Perceptual Categorization: Phenomena

1. Defining categories and their structure
2. Effects of perspective viewing conditions on categorization
3. Does *part structure* help in categorization
4. Contextual effects on categorization
5. Visual agnosia

PART 1 √
Perception Phenomena

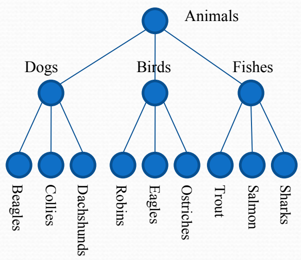
PART 2
➢Categorization
Categories
Perspective viewing
Part structure
Context
Visual agnosia

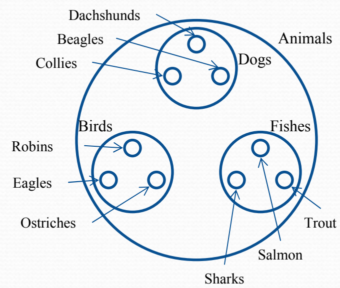
PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Perceptual Categorization: Defining categories

- Categorical structure is largely hierarchical
  - Dog < Mammal < Animal < Living thing …
- Two ways of representing:
  1. Hierarchical trees
  2. Venn diagrams





Perceptual Categorization: Defining categories (cont.)

- Variations within each category
  - Not all dogs look alike, nor all birds, nor cars
  - What is the basis of categorizing objects in a category?
- Classical approach: Aristotle
  - Category was designated by a set of *rules*
    - **Necessary** and **sufficient conditions** for membership
    - Conditions: List of properties that object must have
    - Example: Triangle (closed polygon, three lines)

Perceptual Categorization: Aristotelian view

- Binary category membership
  - Either in category or not
- Is it good at explaining natural perceptual categories?
- Ludwig Wittgenstein (1953) said “No”.
  - Name features common to all games
  - Family members resemblance, but no necessary or sufficient condition definition

Perceptual Categorization: *Prototype*

- Eleanor Rosch, UC Berkeley (1970s)
- All natural categories might be structured in a similar way in terms of a central or ideal example
- This is called Prototype
- Prototype is an *average* member
  - ‘Doggiest’ possible dog

Perceptual Categorization: *Aristotelian vs Prototype*

- Rule-based vs instance-based representation
- Binary versus graded membership
  - How *doggy* a dog is?
- Prototypes are used naturally
  - Chihuahua rated poorly as dogs than beagles

Perceptual Categorization: Levels of categories

- At which hierarchical level do we categorize an object?
  - Lassie < Dog < Mammal < Animal < … ?
- Most people identify object at an *intermediary* level
- Rosch defined it as *basic-level category*
- Superordinate categories: above basic
- Subordinate categories: below basic

Perceptual categorization: Basic-level categories

- Highest level category such that:
  1. Similar shape
  2. Similar motor interactions
     - Piano, guitar
  3. Common attributes

Perceptual Categorization: Entry-level categories

- Example:
  - Category: Bird
    - Robin, sparrow: identified as ‘birds’
    - Ostrich: identified as ‘ostrich’
- For some basic-level categories with *wide variety*:
  - *Typical* objects are classified at basic level
  - *Atypical* objects are classified at *subordinate* level
- Jolicoeur (1984) called them entry-level

Categorization: Perspective Viewing

- Perspective views influence speed and accuracy of recognition
- Some views of objects are easier to recognize than other

PART 1 √
Perception Phenomena

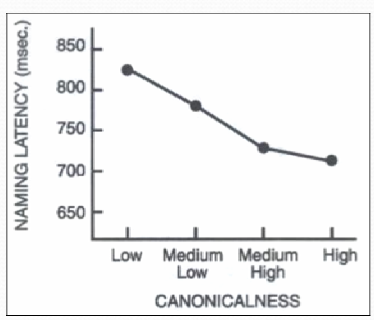
PART 2
➢Categorization
Categories
➢ Perspective viewing
Part structure
Context
Visual agnosia

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Categorization: Perspective Viewing

- Experiment: Palmer, Rosch and Chase (1981)
- Subjects rated many views of the same object
  - *Canonical Perspective*
- Other subjects named entry-level category of many objects
  - Latency was noted



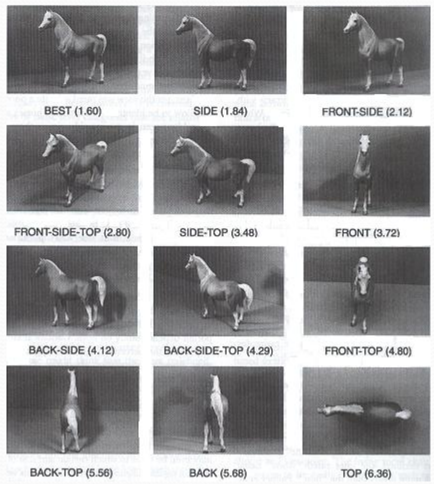
PART 1 √
Perception Phenomena

PART 2
➢Categorization
Categories
➢ Perspective viewing
> Canonical view
Priming effect
Orientation effect
Part structure
Context
Visual agnosia

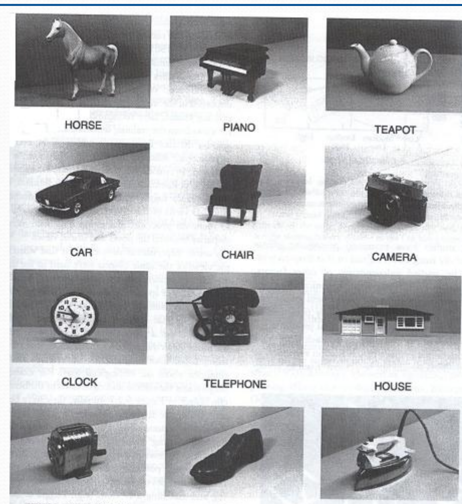
PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Categorization: Perspective Viewing



Categorization: Perspective Viewing



Perspective Viewing: Canonical view hypotheses

- Hypotheses:
  1. Frequency hypothesis
     - Frequently seen views are more canonical
     - But cups seen from above are not
  2. Maximal information hypothesis
     - Views that provide more information about shape and use of object are more canonical
     - Best views tend to show multiple sides
- Both hypotheses are true to some extent

Perspective Viewing: Relation to Priming effect

- Priming effect (Bartram, 1974)
  - Two sets of images shown. Latency noted.
  - Categorizing is faster and more accurate if the object is presented a second time
  - Heightened state of readiness
  - Repetitions need not be exact replica
    - Different perspective view may be presented
- Irving Biederman used this to study the effect on perspective viewing on categorization

Perspective Viewing: Priming effect

- Modification in position, reflection or size does not affect priming effect
- Changes in perspective does
- However, if same parts are visible in different perspective, then no effect

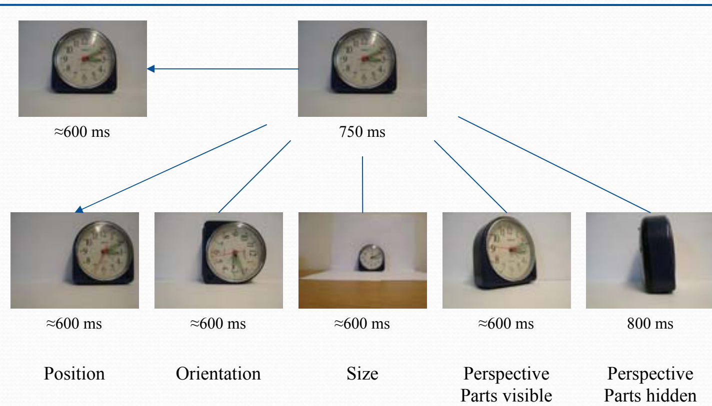
PART 1 √
Perception Phenomena

PART 2
➢Categorization
Categories
➢ Perspective viewing
Canonical view
> Priming effect
Orientation effect
Part structure
Context
Visual agnosia

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Perspective Viewing: Priming effect



PART 1 √
Perception Phenomena

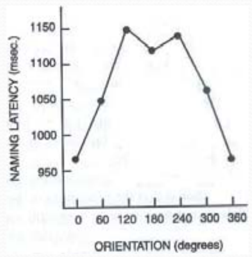
PART 2
➢Categorization
Categories
➢ Perspective viewing
Canonical view
> Priming effect
Orientation effect
Part structure
Context
Visual agnosia

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Categorization: Orientation effect

- Rotation of object along line of sight
- Pierre Jolicoeur (1985)
  - Faster categorization of objects in their normal, upright orientation
- Orientation effects diminish with practice
  - People may store multiple representations of the same object at different orientations



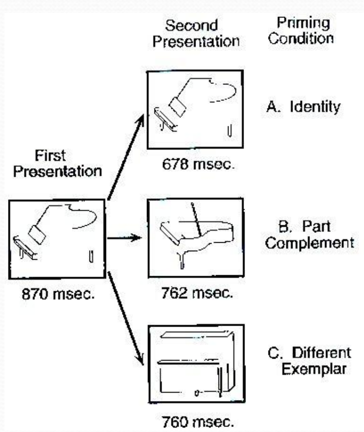
Categorization: Effects of Part structure

- Biederman and Cooper (1991)
- 2 experiments
  - Based on priming effect
  - Used line drawings of objects
- Experiment 1
  - In first image, half contours were deleted
  - Compliment image had only those lines
- Experiment 2
  - First image, some *parts* deleted
  - Compliment image has only those *parts*

Part Structure: Experiments

- Identity priming
  - Same set was used in two trials
  - Just for baseline
- Compliment priming
  - Complement sets were used in two trials
- Different exemplar priming
  - A totally different perspective view was used in the second trial

Part Structures: Results of experiments



PART 1 √
Perception Phenomena

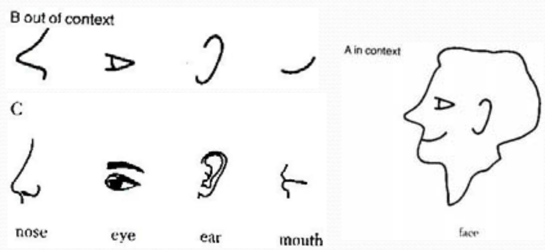
PART 2
➢Categorization
Categories
Perspective viewing
➢ Part structure
Context
Visual agnosia

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Categorization: Contextual effects

- Depends upon prior knowledge
- Depends on surroundings in the view



PART 1 √
Perception Phenomena

PART 2
➢Categorization
Categories
Perspective viewing
Part structure
➢ Context
Visual agnosia

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Categorization: Visual Agnosia phenomenon

- Brain damaged patients
- Inability to categorize previously known objects
- Apperceptive agnosia
  - Sensory processing damaged
- Associative agnosia
  - Perceptual part intact, but association lost
- Prosopagnosia
  - Cannot recognize faces visually

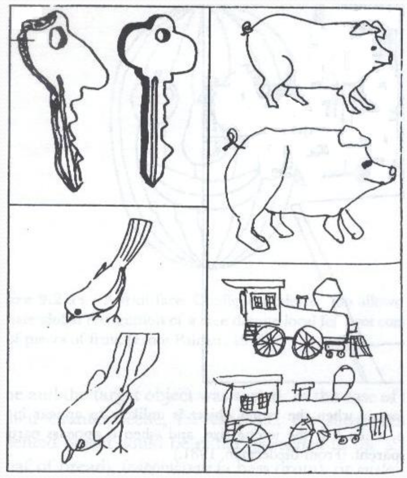
PART 1 √
Perception Phenomena

PART 2
➢Categorization
Categories
Perspective viewing
Part structure
Context
➢ Visual agnosia

PART 3
Theories of Categorization

PART 4
Recognizing letter & word

Visual agnosia



Recap

- Perception of function
  1. Direct (affordances)
  2. Indirect (categorization)
- Categorization
  - Categories (basic-level, entry-level)
  - Effects of perspective on categorization
  - Effects of part structure
  - Effects of surrounding context
  - Visual agnosia is related to categorization

Theories for Object Categorization

- How objects might be perceived in the visual human system
- Most Prominent:
  - Recognition by Components (RBC) Theory
  - Irving Biederman (1985,1987)
  - Also called Geon theory

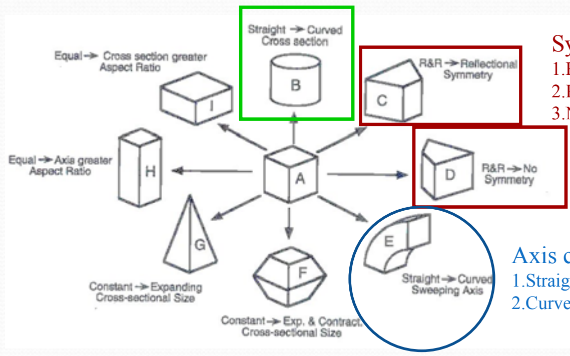
Recognition By Components Theory

- Objects can be specified as spatial arrangements of primitive volumetric components called *geons*.
- Geons
  - *geometric ions*
  - A set of generalized cylinders which are easily distinguishable from each other.
  - Letters: Words :: Geons: Objects

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
➢Theory of categorization
➢ Recog.by components
Explaining phenomena
Other theories
PART 4
Identifying letter & words

Geons

Cross sectional curvature
1.Straight
2.Curved



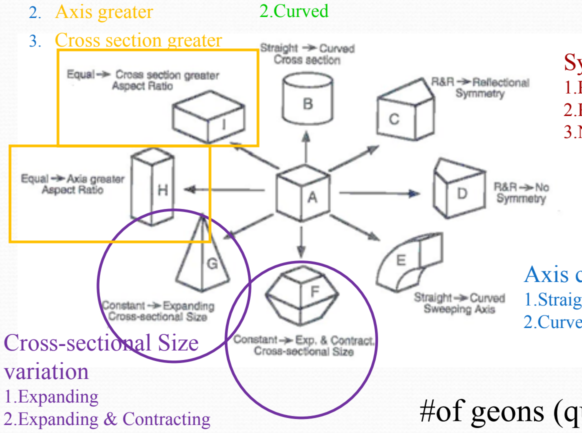
Symmetry
1.Reflectional
2.Rotational
3.None

Axis curvature
1.Straight
2.Curved

Geons

Aspect ratio
1. Equal
2. Axis greater
3. Cross section greater

Cross sectional curvature
1.Straight
2.Curved



Symmetry
1.Reflectional
2.Rotational
3.None

Axis curvature
1.Straight
2.Curved

Cross-sectional Size variation
1.Expanding
2.Expanding & Contracting
3.Fixed

#of geons (qualitatively)= 2*3*2*3=36
#of geons (quantitatively)= 36*3= 108

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
➢Theory of categorization
➢ Recog.by components
Explaining phenomena
Other theories
PART 4
Identifying letter & words

Nonaccidental features

- Properties to identify geons.
- Not dependent on ‘accidents’ of viewpoint.

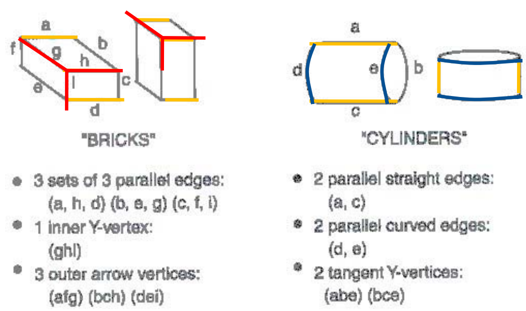


Figure 9.3.3 Nonaccidental properties of two geons. A brick and a cylinder can be distinguished by many properties that are present from all but a few specific viewpoints.

PART 1
Perception Phenomena

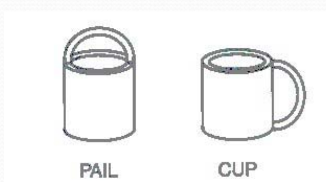
PART 2
Categorization

PART 3
➢Theory of categorization
➢ Recog.by components
Explaining phenomena
Other theories

PART 4
Identifying letter & words

Geon relations

- Spatial relation of geons:: Order of alphabets in words
  - e.g. SIDE-CONNECTED, LARGER-THAN
- 108 different relations
- #of 2 geon objects > 1,000,000



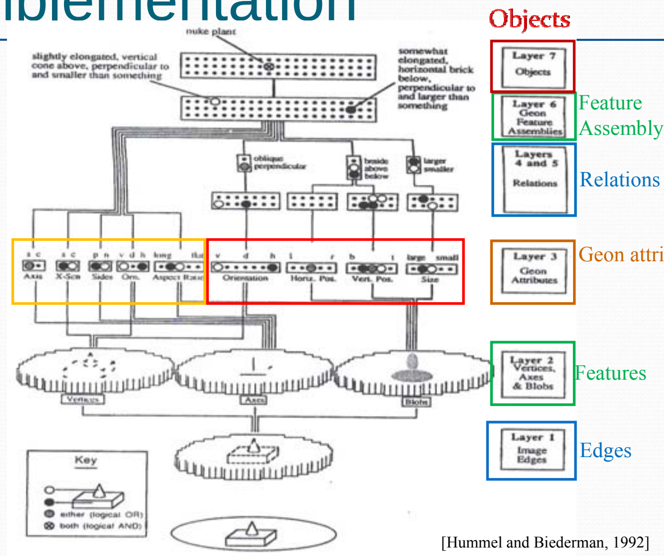
PART 1
Perception Phenomena

PART 2
Categorization

PART 3
➢Theory of categorization
➢ Recog.by components
Explaining phenomena
Other theories

PART 4
Identifying letter & words

A Neural Network implementation



[Hummel and Biederman, 1992]

PART 1
Perception Phenomena

PART 2
Categorization

PART 3
➢Theory of categorization
➢ Recog.by components
Explaining phenomena
Other theories

PART 4
Identifying letter & words

Explaining empirical Phenomena

- Prototypes /typicality
- Basic level/entry level categories
- Perceptual viewing conditions
- Part structure
- Contextual effects
- Visual Agnosia

PART 1
Perception Phenomena

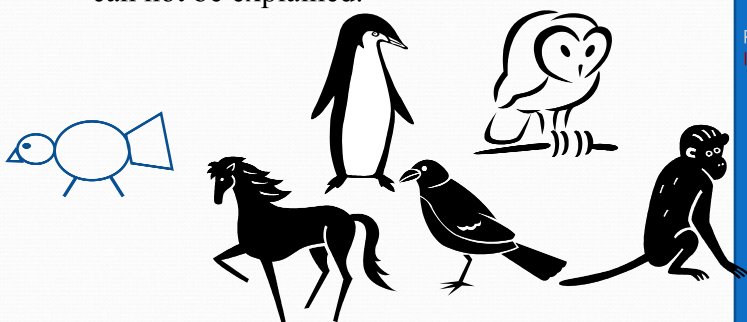
PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
➢ Explaining phenomena
Other theories

PART 4
Identifying letter & words

Prototypes/typicality

- Categorization is function of geon matching
  - ‘Rough’ i.e. qualitative descriptions
  - Subordinate category (fine grained changes) can not be explained.



PART 1
Perception Phenomena

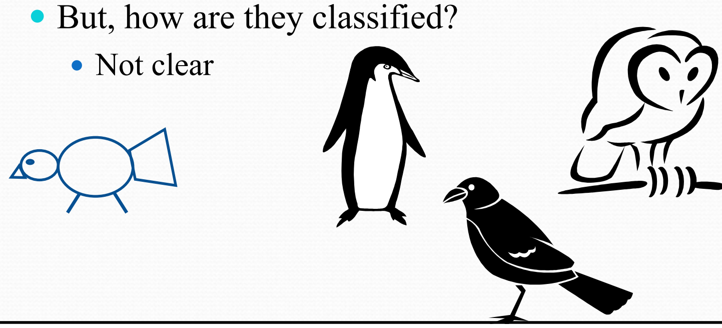
PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
➢ Explaining phenomena
Other theories

PART 4
Identifying letter & words

Basic level/entry level categories

- Typical members closely match the geons for basic level descriptions
- Atypical members do not. Hence not normally classified in Basic level.
- But, how are they classified?
  - Not clear



PART 1
Perception Phenomena

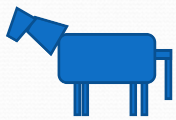
PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
➢ Explaining phenomena
Other theories

PART 4
Identifying letter & words

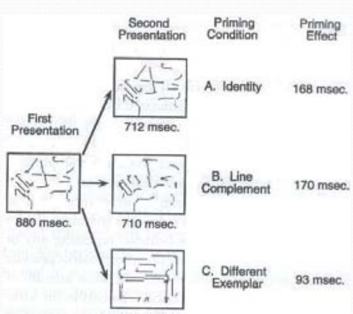
Viewing conditions

- Canonical perspective
  - Some geons get occluded
- Priming effect
  - Not studied



Part structure

- Component geons trigger activation, not lines and edges.
- Half the lines are enough for geon activation.



PART 1
Perception Phenomena

PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
➢ Explaining phenomena
Other theories

PART 4
Identifying letter & words

Contextual effects

- Cannot be explained as RBC looks only at parts of the object.
- But the idea can be extended to 'scenes' whose components are 'objects'.

PART 1
Perception Phenomena

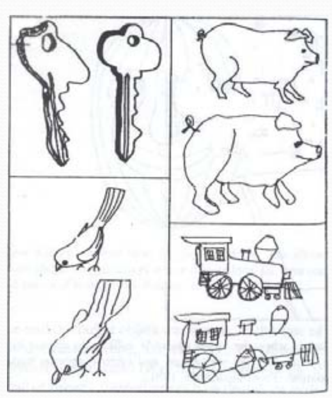
PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
➢ Explaining phenomena
Other theories

PART 4
Identifying letter & words

Visual Agnosia

- All views are 'unusual' to patients.
- Not much known !



PART 1
Perception Phenomena

PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
➢ Explaining phenomena
Other theories

PART 4
Identifying letter & words

Weaknesses

- Lack of representation power
  - 108 cylinders, 108 relations
- Finer discrimination required
  - Dog Vs Cat
  - Face recognition
- Implementation?

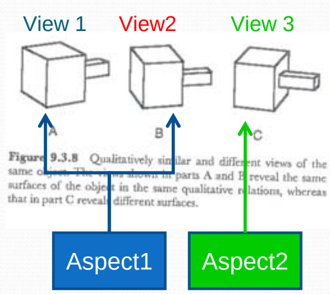
Viewpoint specific theories

- Multiple Views are required
  - 1 view cannot capture the 3D model
  - Multiple 'good' views with low latency
- Hence:
  - Aspect Graphs
  - Alignment with 3-D models
  - Alignment with 2-D view combinations

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
➢Theory of categorization
Recog.by components
Explaining phenomena
➢ Other theories
PART 4
Identifying letter & words

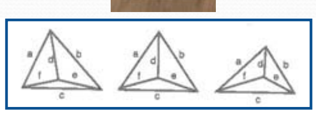
Aspect graphs

- Many views of the same object are actually very similar
- Aspect: *Multiple views* matched to a *common abstract representation*

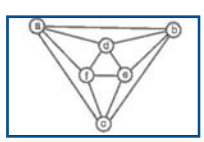


Aspect graphs

- Aspect: *Multiple views* matched to a *common abstract representation*



3 different top views

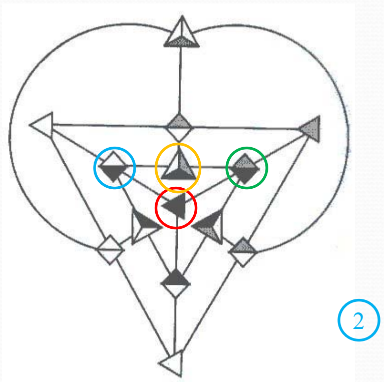


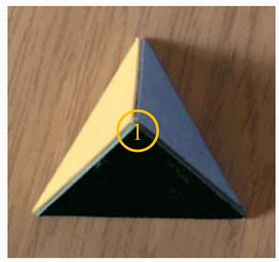
1 common representation i.e. *aspect*

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
➢Theory of categorization
Recog.by components
Explaining phenomena
➢ Other theories
PART 4
Identifying letter & words

Aspect Graphs

- Different *aspects* connected if continuous change takes viewer from one aspect to the other.



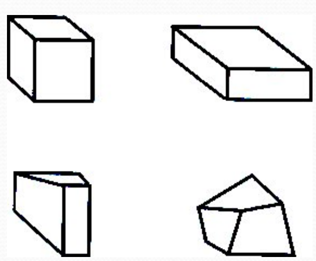


3

4

Aspect Graphs: Issues

- Scalability
- Innate 3-D ability of the brain
- Discrimination (capture *topology*, not geometry)

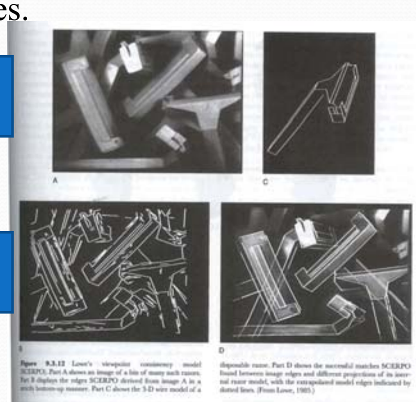


Alignment with 3-D Models

- 3-D Models stored in brain. Mapped to 2-D images.

1. Image

2. Edge features



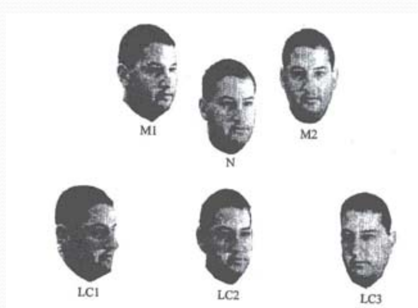
3. Matching with 3-d model

4. Object recognition

- Still top-down

Alignment with 2-D View combinations

- Use a 'few' 2-D views in brain rather than 3-D model.
- A method that can derive ***new*** 2-D views from a few stored ones.



PART 1
Perception Phenomena

PART 2
Categorization

PART 3
➢Theory of categorization
Recog.by components
Explaining phenomena
➢ Other theories

PART 4
Identifying letter & words

Weaknesses

- View point theories don't explain:
  - Innate 3-D ability
  - Novel objects
  - Non rigid objects
  - Part structure
  - Exemplar variation

Identifying Letters and words

- Perceiving letters as well as understanding words.
- Easier than object categorization:
  - Two-Dimensionality
  - Combinatorial structure
- Study:
  - Identifying Letters
  - Identifying within words
  - Interactive activation model

Identifying Letters

- Can be identified using:
  - Templates
  - Structural descriptions
  - Features

	Vertical Lines	Horizontal Lines	Oblique Lines	L-junctions	T-junctions	X-junctions	Free-Ends	Curved Portions	Closed Portions	Reflectional Symmetries
A	0	1	2	1	2	0	2	0	1	1
B	1	3	0	2	1	0	0	2	2	1
C	0	0	0	0	0	0	2	1	0	1
D	1	2	0	2	0	0	0	1	1	1
E	1	3	0	2	1	0	3	0	0	1
F	1	2	0	1	1	0	3	0	0	0
G	1	1	0	1	1	0	3	1	0	0
H	2	1	0	0	2	0	4	0	0	2
I	1	0	0	0	0	0	2	0	0	2
J	1	0	0	0	0	0	2	1	0	0
K	1	0	2	0	2	0	4	0	0	0
L	1	1	0	1	0	0	2	0	0	0
M	2	0	2	3	0	0	2	0	0	1
N	2	0	1	2	0	0	2	0	0	0
O	0	0	0	0	0	0	0	1	1	2
P	1	2	0	1	1	0	1	1	1	0
Q	0	0	1	0	0	1	2	1	1	0
R	1	1	1	1	2	0	2	1	1	0
S	0	0	0	0	0	0	2	2	0	0
T	1	1	0	0	1	0	3	0	0	1
U	2	0	0	0	0	0	2	1	0	1
V	0	0	2	1	0	0	2	0	0	1
W	0	0	4	3	0	0	2	0	0	1
X	0	0	2	0	0	1	4	0	0	2
Y	1	0	2	0	0	0	3	0	0	1
Z	0	2	1	2	0	0	2	0	0	0

[McCelelland & Rumelhart, 1981]

Identifying Letters

- Fuzzy Logic Model of Perception (FLMP)

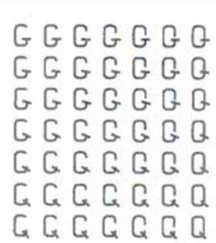


Figure 9.4.2 Ambiguous G/Q stimuli. Seven levels of obliqueness of the straight line segment (row variable) are combined with seven levels of gap size (column variable) to form 49 letter-like stimuli that vary from a prototypical G (upper left) to a prototypical Q (lower right). (From Massaro & Hary, 1986.)

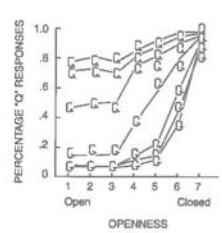


Figure 9.4.3 Results of the G/Q experiment. Percentages of subjects who identified the 49 stimuli in Figure 9.4.3 as a "Q" are plotted as a function of obliqueness of the line and openness of the gap. The lines in the figure show the average predictions of the fuzzy logical model of perception (FLMP). (Data from Massaro & Hary, 1986.)

[Massaro & Hary,1986]

PART 1
Perception Phenomena

PART 2
Categorization

PART 3
Theory of categorization

PART 4
➢Identifying letter & words
➢Identifying letters
Identifying letters in words
Interactive activation model
Alternative explanations

Identifying letters within words

- Letters are **not** detected independently of words.

- HWO NMYA RSETELTE NCA OYU RPTERO WNO
- HOW MANY LETTERS CAN YOU REPORT NOW?

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
Theory of categorization
PART 4
➢Identifying letter & words
Identifying letters
➢Identifying letters in words
Interactive activation model
Alternative explanations

Effects

- Word superiority effect
- Word-nonword effect
- Word-letter effect

[McCelelland & Rumelhart, 1981]

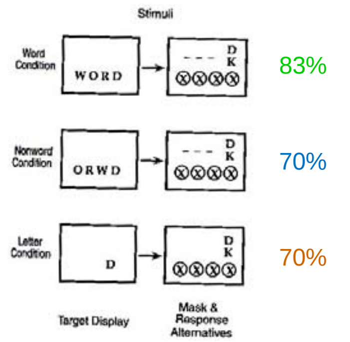


Figure 9.4.5 A controlled experiment demonstrating the word superiority effect. A word, nonword anagram, or single letter was presented briefly, followed by a mask and a two-alternative forced choice. Subjects were more accurate in the word condition than in either of the other two.

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
Theory of categorization
PART 4
➢Identifying letter & words
Identifying letters
➢Identifying letters in words
Interactive activation model
Alternative explanations

Interactive Activation Model

- Proposes a multilayer neural network like model.
  - Feature level
  - Letter level
  - Word Level

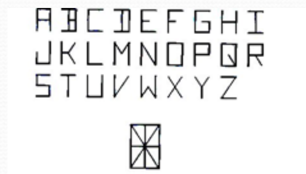


Figure 9.4.7 The letter font used by the interactive activation model. Each letter is composed of a subset of the 12 possible segments shown at the bottom. (From McClelland & Rumelhart, 1981)

Interactive Activation Model

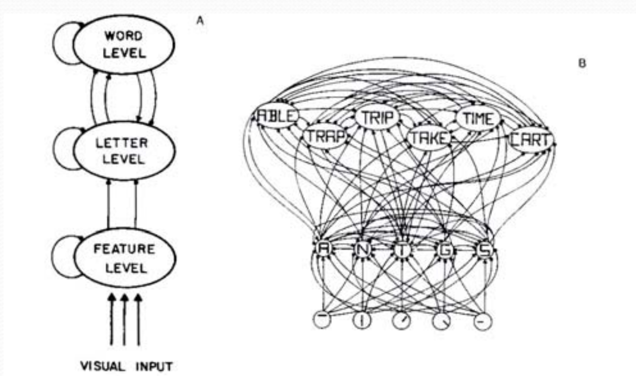


Figure 9.4.6 The architecture of the interactive activation model. Part A shows the overall architecture in terms of how units representing features, letters, and words are connected via excitation and inhibition. Part B shows a small subset of the individual units and connections in the network. (See text for details.) (Part A from McClelland & Rumelhart, 1981. Part B from Rumelhart & McClelland, 1986.)

PART 1
Perception Phenomena

PART 2
Categorization

PART 3
Theory of categorization

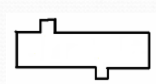
PART 4
➢Identifying letter & words
Identifying letters
Identifying letters in words
➢Interactive activation model
Alternative explanations

Alternative Explanations

- Word shape
- Serial Letter recognition
- Parallel recognition
  - Moving window effect
  - Boundary effect

Word Shape

- We recognize a word is the pattern of ascending, descending, and neutral characters [James Cattell, 1886]



test	Error rates	Explanation
tesf	13%	Consistent word shape
tesc	7%	Inconsistent word shape

PART 1
Perception Phenomena

PART 2
Categorization

PART 3
Theory of categorization

PART 4
➢Identifying letter & words
Identifying letters
Identifying letters in words
Interactive activation model
➢Alternative explanations

Word Shape Vs. Letter Shape

- Letter shape more important than Word shape [Monk & Hulme, 1983]

than	Same Word shape	Different Word shape
Same letter shape	tban 15% missed	tnan 19% missed
Different letter shape	tdan 8% missed	tman 10% missed

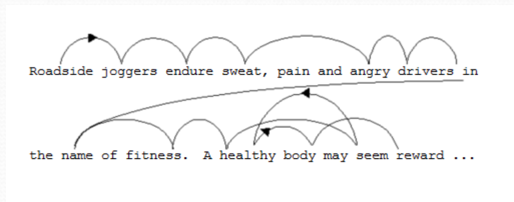
Serial letter recognition

- Analogy to dictionary [Gough, 1972].
  - Start with 1st letter, then 2nd and so on.
- Search for a letter in random strings.
  - 3rd letter 30 ms, 4th letter 40 ms.
- Bigger words take longer to recognize.
- Effects
  - NOUTH
  - SORTH
- Cannot explain word superiority effect

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
Theory of categorization
PART 4
➢Identifying letter & words
Identifying letters
Identifying letters in words
Interactive activation model
➢Alternative explanations

Parallel letter recognition

- Moving window effect [McConkie & Rayner 1975]



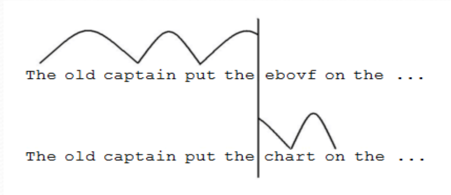
- Fixate on words (200-300ms), then saccadic movement (20-35ms).
  - Fovea (3 or 4 letters)
  - Neighboring (8 or 9 letters)
  - Parafovea (15 to 20 characters)

Moving window effect

Window size	Sentence	Reading rate
3 letters	An experimxxx xxx xxxxxxxxx xx	207 wpm
9 letters	An experiment wax xxxxxxxxx xx	308 wpm
15 letters	An experiment was condxxxxx xx	340 wpm

PART 1
Perception Phenomena
PART 2
Categorization
PART 3
Theory of categorization
PART 4
➢Identifying letter & words
Identifying letters
Identifying letters in words
Interactive activation model
➢Alternative explanations

Invisible boundary effect



[Rayner, 1975]

Word shown	Properties	Speed
chart	Identical word (control)	210ms
chovt	Similar word shape Some letters in common	240ms
chyft	Dissimilar word shape Some letters in common	280ms
ebovf	Similar word shape No letters in common	300ms

Summary

- Part 1: Perception of function phenomena
  - Direct Vs. Indirect
- Part 2: Categorization phenomena
  - Parts, categories, viewpoints, agnosia
- Part 3: Theory of categorization
  - Recognition By Components
- Part 4: Recognizing letters and words
  - Interactive Activation model