Object Recognition & Categorization

Rhian Davies

CS532

Information Visualization: Perception For Design
(Ware, 2000) pp 241-256

Vision Science (Palmer, 1999) - pp 416-436, 561-
563

Object Perception and Object Categorization

- 2 theories of object recognition
- object display and object based diagrams
- categorization (Aristotle to Rosch)
- effects
- visual agnosia
- theories of object categorization
- object file

Two Theories of Object Recognition

- **image-based**

- 'snapshot'

- recognize previously seen images
- priming effect

- **structure-based**

- primitive 3-D parts

- rapid recognition of two distinct images as being similar
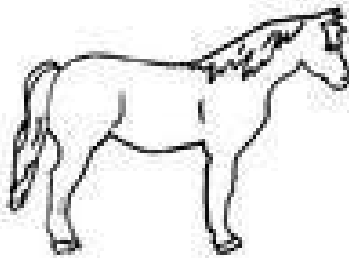
Evidence for Image-based

- Standing et al. (1970)
  - 2560 images, 1 every 10 seconds
  - recognition rate over 90%
- Pavio & Csapo (1969)
  - identification at rate of 16 images per second
- Priming
  - Kroll & Potter (1984)

Priming
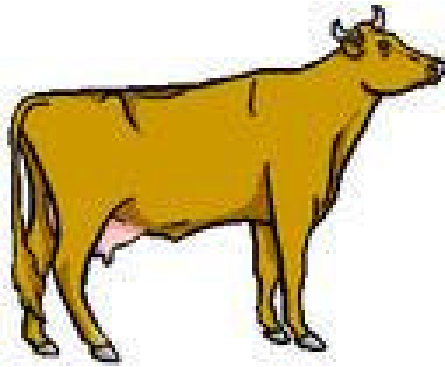
Priming

Applications for Images in User Interfaces

- Icons
  - trigger activation of related concepts
  - pictorially represented
- Searching
  - priming (searching patterns in database)
  - rapid burst of images
- Personal Image Memory Bank ???

Evidence for Structure-Based

http://www-users.cs.umn.edu/~echi/tutorial/perception2000/2000-05-Ware-X2KObjects.pdf
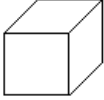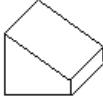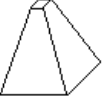
Geon Theory(Biederman)
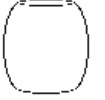
- cross-sectional curvature
  - straight or curved
- symmetry
  - asymmetrical, reflectional, reflectional and rotational
- axis curvature
  - straight or curved
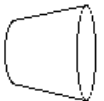- size variation
  - constant, expanding & contrasting, expanding

Geon Theory

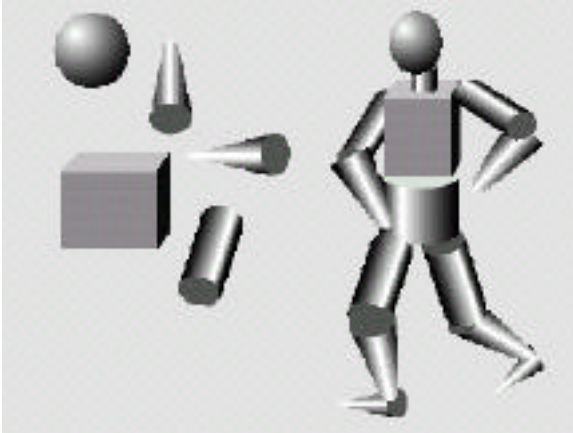- 2(cross-sectional) * 3(symmetry) * 2(axis) * 3(size variation) = 36 qualitatively different geons

  PLUS:
- aspect ratio
  - approximately equal, axis greater, cross-section greater
- total geons: 36 * 3 = 108

Cube	Wedge	Pyramid	Cylinder	Barrel
Straight Edge Straight Axis Constant	Straight Edge Straight Axis Expanded	Straight Edge Straight Axis Expanded	Curved Edge Straight Axis Constant	Curved Edge Straight Axis Exp & Cont

Arch	Cone	Expanded Cylinder	Handle	Expanded Handle
Straight Edge Curved Axis Constant	Curved Edge Straight Axis Expanded	Curved Edge Straight Axis Expanded	Curved Edge Curved Axis Constant	Curved Edge Curved Axis Expanded

http://www.pigeon.psy.tufts.edu/avc/kirkpatrick/default.htm#view

Geon Theory

http://www-users.cs.umn.edu/~echi/tutorial/perception2000/2000-05-Ware-X2KObjects.pdf

Testing Type	Can	Handle	Nozzle	Spout
Moved Geon				
Deleted Geon				
Retained Geon				

http://www.pigeon.psy.tufts.edu/avc/kirkpatrick/threegeon.htm

Silhouettes

- easily recognizable
- silhouette boundaries & line drawings excite same neural mechanisms
- canonical silhouettes
  - often the right angle to major plane of symmetry

Silhouettes
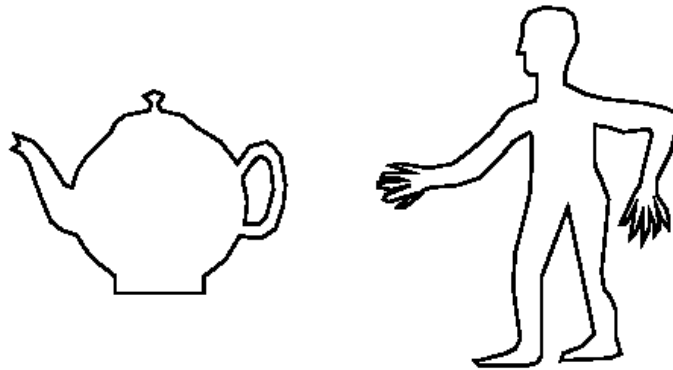
Applications for Structure-Based Theories in User Interfaces

- simplified views easier to read than actual image.
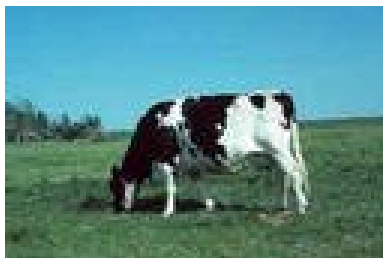
Applications for Both Theories in User Interfaces

- evidence for both
- visual images and 3D-structures are both stored (?)
- images are good -- but use good 2D layout to take advantage of structural representations

Object Display

- Wickens (1992)
- single object integrating a large number of variables
- processed in parallel
- reduces visual clutter
- easier to integrate multiple sources of information

Chernoff Faces

(Chernoff, 1973)

- data variables matched to different facial features
- perceptual space of Chernoff faces probably extremely non-linear
  - more sensitive to changes around eyes than nose

Chernoff Features

Face width	Ear level	Half face height	Eccentricity of upper ellipse of face
Curvature of mouth	Seperation of eyes	Length of nose	Eccentricity of lower ellipse of face
Length of mouth	Slant of eyes	Half length of eye	Position of centre of mouth
Position of pupil	Height of eyebrow	Angle of brow	Eccentricity of eyes
Length of brow	Radius of ear	Nose width	Height of centre of eyes

http://www.epcc.ed.ac.uk/computing/training/document_archive/SciVis-course/SciVis.book_47.html

Geon Diagram

- geon display v.s. UML model
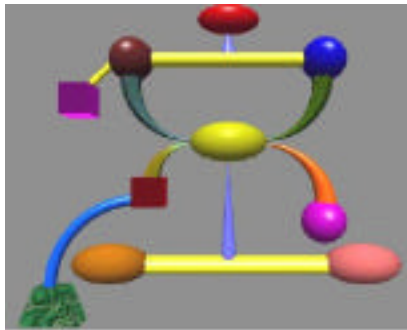
Pourang Irani & Colin Ware

Memory test

- 15 sec exposure
- Delay one hr
- Recognition test
- UML 48% errors (chance)
- Geon 24% errors

Indentifying subgraphs

- Subgraph 25% of original
- Permuted layout
- UML 36% errors
- Geon 13% errors
- UML responses 70% longer time

http://www-users.cs.umn.edu/~echi/tutorial/perception2000/2000-05-Ware-X2KObjects.pdf

Geon Display v.s. 2-D Representation

http://www.ccom.unh.edu/vislab/PDFs/IEEEgeon.pdf
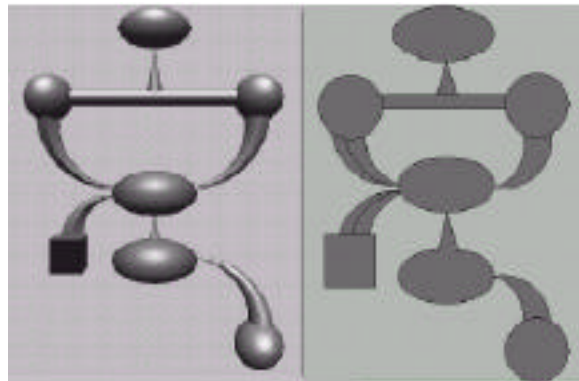
Categorization

- Categorical hierarchies:

  – trees: -Venn diagrams:
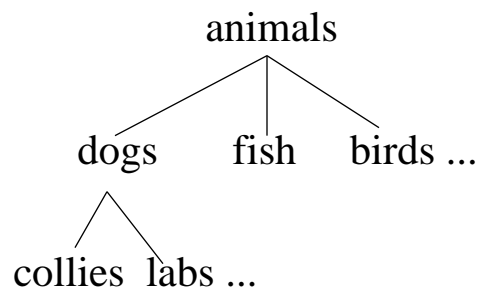
  collies labs ...
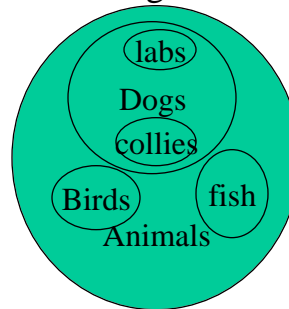
Membership in Categories?

- What condition do exemplars satisfy to be members of a category?

- Aristotle:
  - necessary and sufficient condition
  - e.g.: triangles: closed polygon + exactly 3 straight lines as sides

Language Games

- Wittgenstein(1953)
- language does not have a one-to-one mapping to the world
- words have meaning in context
- different contexts, or games, result in words having different meanings
- the similarity is one of resemblance

Family resemblances

- CDE
- DEF
- EFG
- FGH
  - CDE is in the same category as FGH through family resemblances

    GLOBAL SIMILARITY!

Rosch: Prototype Theory

- natural categories
  - instance based representation (prototype)
  - graded membership
- typicality ratings
- basic (subordinate, super-ordinate) levels
  - similar shape, motor interaction, attributes
- entry-level categories (Jolicoeur, Gluck & Kosslyn, 1984)

Rosh style test:

F E K I G

F U T E G

P U R Y G

F Y R I P

K U R I T

FUKIP
??

KETYG
??

PURYG

??

FURIG

??

F E K I G

F U T E G

P U R Y G

F Y R I P

K U R I T

Prototype:　　　F U R I G

Rosch

- F U K I P
  - speed, accuracy, confidence varies depending on how close to prototype
  - similar to prototype (F U R I G)
  - supports prototype theory

Alternative Hypothesis - Whittlesea

- typicality effects in category learning result from encoding and preserving representations of individual training instances

- confound: FUKIP responded to quickly because of closeness to prototype, or closeness to all individual test items?

http://howard.psych.nwu.edu/psych/people/faculty/paller/cogsci/whittlesea.html

Perspective Viewing Conditions

- 1st order fact: same object

http://psyserver.pc.rhbnc.ac.uk/zanker/teach/PS202/PS202_L2.html

- 2nd order fact
  - perspective effects speed and accuracy

http://psyserver.pc.rhbnc.ac.uk/zanker/teach/PS202/PS202_L2.html

Perspective effects

- canonical perspective
  - Palmer, Rosch, Chase 1981
  - pictures rated as 'best' view named fastest
- frequency effect
  - function of number of times seen from view
- maximal information hypothesis
  - amount of information different views reveal

Perspective Viewing

- priming effects
  - picture presented second time recognized faster
- when does it work?
  - changes OK:
    - Position in visual field, retinal size, mirror image reflection, perspective (with exceptions)
  - changes not OK:
    - perspective changes in such a way that different parts are visible

Perspective Viewing

- orientation effects
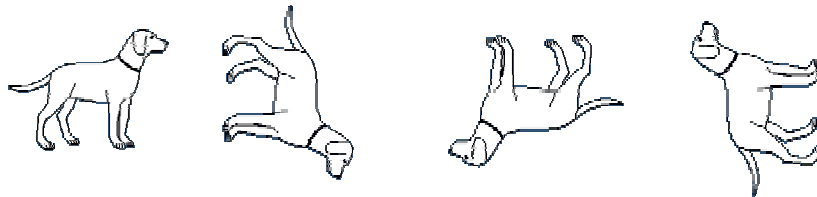
- Jolicoeur, 1985
  - naming latencies suggested we mentally rotate objects to upright position

    http://www.dal.ca/~mcmullen/index.html

Part Structure

- Biederman & Cooper, 1991
- prior presentation prime classification?
    3 conditions:
- identity priming (same)
- line compliment priming (->)
- different exemplar priming (baby-grand -> standup)
- *identity and line almost the same priming*
- *perception of parts plays crucial role*

Contextual Effects

- appropriate context facilitates categorization
- inappropriate context hinders categorization

Visual Agnosia

- unable to correctly categorize common objects
- lack of
    - sensory deficit
    - conceptual deficit
    - deficit in other sensory modality
    - linguistic deficit

Theories of Object Categorization

- Recognition By Components (RBC) theory
    - Biederman (geon theory)
- Piaget - interactionist account
- Edelman - TNGS (theory of neuronal group selection)
- Whittlesea: SCAPE (Selective Construction And Preservation of Experiences) account

TNGS

http://www.univie.ac.at/zoologie/theo/ludwig/EC95/Embodiment.htm
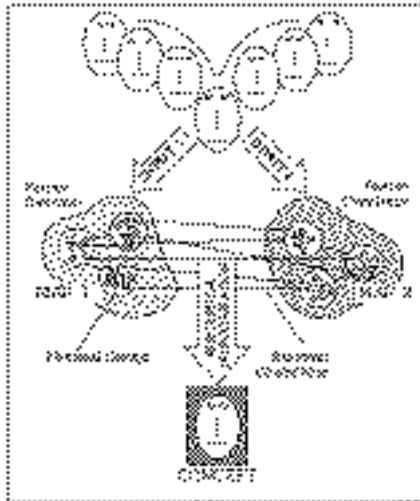
Object Files

- maintains accurate, up-to-date representation of environment
- representational structure
- mediates between low-level sensory & high-level expectations
- result of perceptual analysis

Conclusion

- object recognition
  - image based & structural based theories

- categorization
  - rule-based & prototype theories