Visual and Spatial Imagery/
Knowledge

- Can you imagine an elephant pushing a yellow VW being steered by a chimpanzee?
- Can you get from Sturges to Welles without going outside?
- Which direction is the Bronze Bear facing (N, S, E, W)?
- Alluded to ability/system earlier:
  - Baddeley's Visuo-Spatial Sketched

Questions

- What are the characteristics of visual imagery
- (how do we work with mental images)
- What is the form of the representation?
- Is visual imagery similar to actually seeing?
- Is visual imagery distinct from verbal thought?
- Is visual imagery different from spatial imagery?

Representations

- Representation
  - Internal model of outside world (referent)
  - Preserves/codes the key (useful) features of referent
  - Represented features can be used to guide behavior

Problem

- How can we study something so "subjective"
- How to explore the characteristics of someone's visual imagery?
- Problems with Introspection
  - No way to confirm or compare

How are images represented

- Analog vs. Propositional representation
- Representation -- internal "knowledge" of referent
- Analog representation
  - Mimics structural characteristics of referent
    - Continuous
    - Reference frame (for relative positions)
- Propositional representation
  - Assertions possessing truth value
  - Anderson's ACT

Propositional Representation
- rocking chair left of couch
- candy in candy dish
- rug below coffee table
- window behind couch

Analog Representation
- rocking chair left of couch
- candy in candy dish
- rug below coffee table
- window behind couch
Processing Spatial Information

- Different types of representations useful (easier) in different situations
- Analog (representing space with space)
  - Easy to measure/estimate distance
  - Easy to determine relative direction
- Propositional (representing space verbally)
  - Easy to create directions
  - Easy to communicate directions
  - Easy to refer to locations

Shepard and Metzler (1971) and Cooper & Shepard (1973)

- How are mental images represented?
- Studied the manipulation of mental images
  - Mental rotation
- Ask subjects to manipulate images
  - Measured time required to do so

Task

- Drawings of 3-D objects
  - Decide if same or different
  - A) frontal plane (S)
  - B) depth (S)
  - C) (D)
- Manipulated amount of rotation

Results

- Measured time to make judgment
- RT to make judgment -- degree of rotation
  - Same result if you physically rotated at constant speed

Conclusions

- Evidence for analog representations
  - (manipulate continuously)

Kosslyn, Ball, & Reiser (1978)

- Mental map experiment
- Map
  - 7 landmarks
Procedure

- studied map -- reproduce
- task -- given a landmark
- 5 seconds later given a 2nd landmark
- scan from one to the other
- press button when reach 2nd landmark

Results

- Mental scanning time - function of "distance"
- Supports analog representation
  - longer "physical distance" = longer mental distance

Maps and Navigation

- Can acquire different types of information about an environment
  - Survey knowledge - bird's eye view (map)
  - Route knowledge - how to navigate between locations

Route Knowledge

- Navigation from one landmark to another
  - "turn left when you get to the church"
  - remembering which way to turn at a given landmark without having to see it
  - egp-centered frame of reference
  - obtained through navigation of route

Survey Knowledge

- internal cognitive map (analog representation)
- world-centered reference frame
- can be abstracted from route knowledge or a map
Route vs. Survey Knowledge

- Route vs. Survey knowledge
  - Route knowledge supports tasks requiring an ego-centered perspective — pointing directions, calculating time to reach destination
  - Survey knowledge supports tasks requiring a world-centered perspective — judging absolute location, direction, or distance

Acquiring Knowledge

- With training, route knowledge can lead to survey knowledge, however...
- Survey knowledge does not easily lead to route knowledge: it is difficult to obtain route knowledge without actual navigation
- With irregular layouts — learning through navigation may distort survey representation

Visual imagery

- Similar to visual perception?
- Kosslyn research -- scanning times suggest similarity

Resolution effects

- Kosslyn (1975)
  - resolution effects with mental images?
- one experiment:
  - imagine an elephant sitting next to a rabbit
    - does the rabbit have whiskers?
  - imagine a rabbit sitting next to a fly
    - does the rabbit have eyebrows?
  - Which image of a rabbit was larger?
  - Which had more detail?
**Results**

- Speed with which people made judgments about an image depended on the size of the image
  - larger images -- higher resolution -- more details
  - follow-up experiment -- switched sizes
    - (to rule out that larger animals = more detail)
  - imagine a monster fly next to a pygmy elephant
  - results again consistent with size of image

**Symbolic Distance Effect**

- In vision
  - making a comparison
  - RT increases with "difference"
  - ex: RT to compare two angles -- which is larger
    - fast to compare very distinct angles
    - slower to compare similar lines

**Paivio (1978) -- Symbolic Distance Effect in Images**

- Had people comparing imagined angles
  - Decide which one was larger
  - Did this by having people imagine clocks
    - compare angles between hands
    - ex: 4:40 vs. 9:55
    - ex: 2:20 vs. 11:30 -- easy
    - ex: 3:10 vs. 11:05 -- harder
  - Found symbolic distance effect for images

**Similarity between imagery and perception**

- How might we explain this?
  - Same mechanisms?
    - create a visual image
      - activate parts of brain used for visual perception?
    - Interact with (e.g., scan)
      - using same processes used to scan actual image?
  - Image -- top-down activation of visual areas
    - As opposed to bottom-up

**Evidence that imagery uses "perceptual machinery"**

- Imagery should activate similar regions of brain
  - Kosslyn et al (1993) -- PET evidence
  - Subjects created visual images -- PET scanner
    - imagine a block letter within a 4x5 grid vs. actually viewing one
  - make judgments does mark fall on or off letter
**Results**
- Activity found in visual cortex
- Similar pattern to what was found when subjects performed "visual version"
- Activity higher during imagery
  - (imagery harder than perception?)

**Roland & Friberg (1985)**
- Activation - specific to modality
- PET study
- Auditory imagery task (imagine a tune)
- Visual imagery task (walk in your neighborhood)
- Results:
  - Auditory imagery
    - Activation of auditory cortex / not visual cortex
  - Visual imagery
    - Activation of visual cortex / not auditory cortex

**Imagery can "prime" detectors**
- Letter identification task -- more accurate faster if just "saw" letter
  - repetition priming -- warm up the detectors
  - (implicit memory)
- Farah, Peronnet, Gonon, & Girard (1988)
- Similar experiments with imagery
  - imagine a letter -- identify a degraded letter
  - better when they matched
    - (imagine H -- presented with H)

**Other evidence -- perception and imagery differ**
- Chambers & Reisberg (1985) ambiguous figures

**Chambers & Reisberg Findings**
- ambiguous figures -- can store only one interpretation
- shown briefly -- can’t reinterpret based on image
- draw from memory -- now can reinterpret
- Visual images -- not as flexible as visual perception
- Some counter evidence (book)

**Difficulty may be in changing reference frame**
- changing reference frame
  - e.g., change top to side, front to back, etc.
Summary

- Imagery and perception
  - Similar form of representation
  - Interaction with / manipulation -- similar phenomenon
  - Likely involve common brain mechanisms

- But:
  - May differ in terms of ability to reinterpret
    - Images -- interpretation attached

Images: Visual or Spatial Representations?

- Spatial
  - Not tied to specific modality
  - Abstract representation of spatial relations
  - Analog in nature
- Visual
  - Representation based on visual encoding
  - Representing appearance
  - Uses visual system

Evidence for Spatial Representation

- Compare performance:
  - congenitally blind subjects and sighted subjects
  - No visual representations
  - Spatial representations
- Kerr (1983)
  - Replicated Kosslyn et al’s “Island” scanning exp.
  - Blind subjects -- learned layouts by feel
  - Results -- replicated original results
    - RT increased with “scanned” distance
- Marmor & Zabeck (1976) -- same results as sighted for mental rotation

Both visual and spatial imagery?

- How to determine if these are separate processes?
- Brooks (1968) -- interference task
  - Verbal vs. visuo--spatial task
    - Determine if visual tasks interfere with spatial tasks
      - And vice versa

Baddeley & Lieberman (1980)

- used matrix filling task
- Imagine 4x4 matrix
  - Second row, second column -- starting point

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Two types of interference tasks

- Spatial vs. Visual
  - Spatial -- Patterned hand movement (eyes closed)
  - Visual -- brightness discrimination
Spatial task produced interference

Visual task did not

Evidence for spatial imagery
(as well as visual imagery)

Cognitive Neuropsychology

- Brain damage -- lose one function & spare others
  - patient LH -- auto accident
  - visual agnosia -- impaired at recognizing objects
  - gave a battery of imagery tasks

Visual imagery tasks:

- animal tails (Does a rat have a long tail)
- size comparison (which is larger, a donkey or a horse)
- state shapes (Is the shape of Illinois more similar to Indiana or Colorado)
Spatial imagery tasks:
- letter rotation (if you take capital N and rotate it 90° clockwise -- letter?)
- 3-D rotation (Shephard & Metzler task)
- Mental scanning (Kosslyn map task)
- Matrix memory
- Matrix memory (what we just did)

LH
- Visual imagery tasks -- performance decrement
- Spatial imagery tasks -- normal to above normal performance

Picture superiority effect
- Better memory for pictures than for words
- Why?
- Paivio -- Dual Code Hypothesis
- How do we store visual information in memory?
  - Use verbal code (propositional)
  - Use non-verbal code (analog)
- Picture superiority effect
  - Picture -- stored in both codes
  - Words -- typically stored in verbal code

Other Evidence
- Better memory for concrete words than abstract words
  - concrete: pencil, cup, chimney, radiator, tree, mountain, table, mailbox, guitar
  - abstract: month, virtue, skill, hunger, idea, mistake, compliment, theory, event
- Why would a Dual-Code theory predict this?
  - Concrete -- imageable
    - activate both verbal and nonverbal codes
    - more retrieval paths / cues

Propositional vs. Analog (Part II)
- Began this section -- evidence for analog representation
- Evidence -- We have analog representations
- Rule out propositional representations?
  - No
- Paivio’s dual coding hypothesis
  - Have both at our disposal

Evidence for propositional representation
- Hierarchical representation of space
  - Reno east of Los Angeles?
  - Montreal north of Seattle?
  - Rochester south of Boston?
- Book -- study by Stevens and Coupe (1978)
Stevens & Coup (1978)
- Subjects learned maps with:
  - Counties (superordinate)
  - Towns (subordinate)
- Task: judge relative locations of towns x & y
  - east of / south of / etc.
- Results
  - East-West judgments better with left maps
  - North-South judgments better with right maps

Hemispheric Specialization
- Left hemisphere
  - Categorical representations
  - (propositional)
  - Above, below, right, left
- Right hemisphere
  - Continuous representations
  - (analog)
  - Relative distance encoded

Kosslyn (1989)
- Asked people to make
  - Categorical (propositional) judgments
  - Or
  - Continuous (analog) judgments
- Used lateralized stimulus presentations

Laeng (1994)
- Lateralized Damage
  - stroke
- Pictures (same or diff)
  - Left Hemisphere Patients
    - More target confusions with categorical transformation
  - Right Hemisphere Patients
    - More target confusions with coordinate transformation

Lateralized stimuli
- Right visual field (RVF)
  - Projects to left hemisphere (LH)
- Left visual field (LVF)
  - Projects to right hemisphere (RH)

Tasks
- Categorical
  - Dot above or below line
- Coordinate
  - Dot near or far from line
- Note -- identical stimuli

Laeng (1994)
- Lateralized Damage
  - Stroke
- Pictures (same or diff)
  - Left Hemisphere Patients
    - More target confusions with categorical transformation
  - Right Hemisphere Patients
    - More target confusions with coordinate transformation
End Spatial Knowledge