Representing space

What we see

• Two dimensions
• Monocular depth cues
• Binocular depth cues

What we “see”

• 3D structure
• Not exactly like what we see at a given instant
• Visual imagery?
• Something more succinct?

Possible types of representations

• Analog
  – Preserves properties of thing it represents
  – (Thing it represents: the “referent”)
  – “To scale”
  – Often, idea is that representation duplicates the perceptual experience itself

Possible types of representations

• Propositions
  – A is north of B
  – B is south of C
  – Modality-independent
    • Not visual or spatial
    • Could also represent “A is a nice city to visit”
Propositional representations

• More parsimonious: A-centered
  – C is 6 mi east of A
  – B is 4 mi south of A

• Less parsimonious (but more direct):
  – A is 6 mi W of C
  – C is 6 mi E of A
  – A is 4 mi N of B
  – B is 4 mi S of A
  – B is 45, 6W of C
  – C is 4N, 6E of B

• What if we add new city D?

Propositional representations

• More parsimonious: A-centered
  – C is 6 mi east of A
  – B is 4 mi south of A
  – D is 6 mi east and 4 mi S of A

• Less parsimonious (but more direct):
  – A is 6 mi W of C
  – C is 6 mi E of A
  – A is 4 mi N of B
  – B is 4 mi S of A
  – B is 45, 6W of C
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Maps & Navigation

• Survey knowledge
  – “Bird’s-eye”
  – Layout

• Route knowledge
  – Point A to Point B

Survey knowledge

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  – B is 45, 6W of C
  – C is 4N, 6E of B
  – A-D
  – D-A, B-D, D-B, C-D, D-C
Survey knowledge

Survey from route?

- Maybe
  - If fairly regular roads (Philly)
  - If irregular, no luck (Rochester)

- Routes: probably learning multiple views

- Goal-dependent (Taylor, Naylor, & Chechile, 1999)
  - Want to learn route, or layout?

Spatial hierarchies

- Superordinate: Nevada is east of California
- Subordinate: BUT Reno isn’t east of LA

Propositional that complements analog?

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<thead>
<tr>
<th>a</th>
<th>y</th>
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<tbody>
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<td>x</td>
<td>b</td>
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Subordinate: E/W
Superordinate: E/W
Faster to judge

Dual representation

- Kosslyn (1987)
  - LH: categorical (inside, above)
  - RH: metric, spatial
Visual imagery

• Navigating your room in dark
  – Did you visualize?

• Is visual imagery necessary, or epiphenomenal?
  – (It happens but isn’t the knowledge itself)

Do we “need” imagery?

• Selective interference (Segal & Fusella, 1970)
  – Visually image an object (tree), OR
  – Auditorily image a sound (typewriter)
  – Monitor for
    • Weak visual (blue arrow) AND
    • Weak auditory (harmonica)
  – Worse when imaging than not imaging
  – Worse when imaging in same modality
    • Sound-image competes (interferes) with sound,
    • Visual-image with actual image!

Do we “need” imagery?

• Mental rotation (Shepard & Metzler ’71)
  – Compare two shapes at different orientations: same or different shape?
  – Linear relation between angular distance and RT
  – Objection: # of eye movements back & forth determine RT
    (Just & Carpenter ’76)
  – But still holds with sequential presentation
    • Can’t look at both at once (Shepard & colleagues)

Do we “need” imagery?

• Laeng & Tedorescu (2002)
  – Eye movements when looking at picture of object
    similar to eye movements when imaging that object

Do we “need” imagery?

• Kosslyn: map-scanning experiments
  – Scanning an image = scanning real map
  – Procedure:
    • Learn (fictitious) map (tree, pond, well, grass…)
    • Then, image map
      – Focus on the tree
      – Now imagine black speck moving from there to pond
      – (Sometimes no pond; measure time when there is)
    – Longer distance = longer scan time!

Imagery = Perception?

• One argument: No, imagery is already some sort of abstracted representation.
  – The imaged object can’t be reinterpreted
    • Chambers & Reisberg (1985): bunny-duck
  – Yes, you can reinterpret mental images
    • Finke, Pinker, & Farah (1989)
      – Imagine D rotated left 90° and put atop a J
Imagery = Perception?

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  - The imaged object can't be reinterpreted (Chambers)
  - Yes, you can (Finke, Pinker, & Farah)

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  - Peterson et al. (1992): difference in *attention*
    - Reinterpreting a feature (J-curve-handle), or
    - Reinterpreting reference frame (front of duck =back of rabbit)
    - BOTH types of reversal occur

- Mast & Kosslyn (2002): better mental-rotators show effect more

Are visual images really visual?

- What if you can't see?
  - Kerr (1983): map-scanning in congenitally blind subjects
    - Teach layout on a board (raised objects)
    - Focus on named object
    - Imagine raised dot moving to 2nd object
    - Increase in response time with distance!
  - Representation of space isn't necessarily visual

- Farah: brain damage evidence
  - Visual deficits correlate w/ imagery deficits
    - Image H or T, then detect H or T
      - Facilitated only by identical letter
      - Matching effects found in ERP over visual cortex
  - Roland & Friberg (1985)
    - PET shows visual cortex activation for visual images but not auditory, & vice versa for A-V

Visual memory
Visual details

- This part isn’t as good as we might think.
  - What color is your front door?
    - [recall vs recognition]
  - Drawing familiar coins
    - Nickerson & Adams (1979): American penny
      - Omits over 50% of features
    - Less than half picked correct from a line-up
    - Jones (1990): # sides on British coins

Visual details

- Change blindness (Simons & Levin '98)
  - Stop a pedestrian, ask for directions
  - DOOR!
  - New person: keeps asking for directions
  - Did you notice a change? Only 50% did!
  - Factors
    - Relevant to task? (penny vs. button)
    - Category change? (age, social category)
    - And yet...
Visual details

• Not so great.
• But what about more large-scale information?

Picture memory

• Uncannily good.
• Shepard (1967)
  – Look at 612 pictures (6s each)
  – Then show in 2AFC task: 97% correct!!
  • After 3 days: 92%
  • After 4 months: 58%
  – Not clear how they’re doing it
  • Could be remembering unusual detail(s)

• Standing (1973)
  – <=10,000 pictures, 5 sec each
  – 2AFC
  – 83% correct

Picture memory

• Uncannily good.
• Shepard (1967)
• Standing (1973)
  • Koustaal & Schacter (1997): age effects
    – YES/NO task
    – Several objects from same category
    – Young adults: 81% yes, 35% FA
    – Older adults: 83% yes, 70% FA

Picture memory

• Picture-superiority effect:
  • PIC1 PIC2 PIC3 better remembered than if shown word list SHELL CAT TREE
  • Why?
    – Paivio (1971) dual coding hypothesis
      • Verbal code (kinda like propositional)
      • Imaginal code (kinda like analog)
      • Pictures have both, words have only one

• Paivio (1971) dual coding hypothesis
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• Alternative hypothesis: context differences
  Words have particularly poor contextual information, while pictures have good context info.
**Picture memory**

- Propositional probably isn’t enough.
- Better to store in analog form, even if we can’t get quite all the details.

**What about other kinds of analog memory?**

**Auditory memory**

- "Abstractionist" accounts of word memory
  - You store only the information relevant to recognizing words.
    - i.e., no information about
      - Talker’s voice
      - How fast it was spoken
      - How talker felt (emotion, health)
      - Background noise
  - Conceptually similar to propositional storage
  - You might store other stuff, but "elsewhere."
    - If the "other stuff" influences memory (e.g., recognition), it has to come in from the outside.

**Auditory memory**

  - Are word representations “abstract”?
  - Presented words from different talkers
    - People were faster to shadow same-voice reps
    - Also spontaneously imitated the talker

**Auditory memory**

- Pisoni & colleagues: variability & language learning
  - English r/l for native Japanese speakers
  - Two kinds of auditory specificity important:
    - Where in the word it occurs (initial vs. final)
    - Variability in talkers
  - Affects both perception and production!

**Auditory memory**

- Speech isn’t stored in abstract form.
- Music may not be, either.
  - People: recognize Happy Birthday in any key *(relative pitch)*
    - *Note: animals aren’t good at this
  - Do we “throw away” pitch information?
• Levitin (1994): production
  – Sing a couple of your favorite songs
  – (Pop songs, not happy birthday)
    • You always hear them at the same pitch level
  – Pitch produced was quite close to pitch of original song (absolute pitch)
  – Similar results for rhythm

• Schellenberg & Trehub (2003), Psych Sci: perception
  – Played familiar theme songs (ER, X-Files, Simpsons)
  – Shifted slightly ± in pitch
  – 2AFC

• Schellenberg, Iverson, & McKinnon (1999): more perception
  – Songs can be recognized from 200 ms excerpt (even 100 ms)
  – Used five “Top 100” songs
  – Match excerpt to each of 5 songs
    • Guessing: 5x4x3x2x1 = 120 combinations
    • At 200 ms: 18/20 listeners above chance

• Not abstract–analog representations more plausible
• Temporal information is important
  – (May also be important for visual memory, even though we didn’t discuss this)