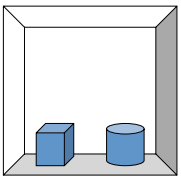
Representing space

## What we see

- Two dimensions
- Monocular depth cues
- Binocular depth cues

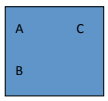


## What we "see"

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

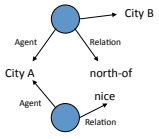
## Possible types of representations

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



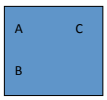

## Possible types of representations

- 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"



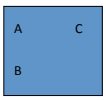
## Propositional representations

- 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 4S, 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 4S, 6W of C
  - C is 4N, 6E of B

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  - B is 4S, 6W of C
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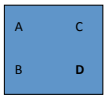
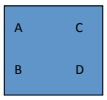
  - **A-D**
  - **D-A, B-D, D-B, C-D, D-C**

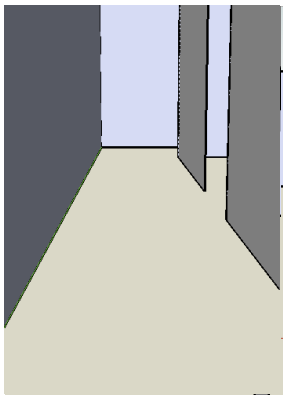



## Maps & Navigation

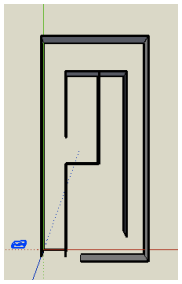
- Survey knowledge
  - "Bird's-eye"
  - Layout
- Route knowledge
  - Point A to Point B







## Survey knowledge



## Survey knowledge

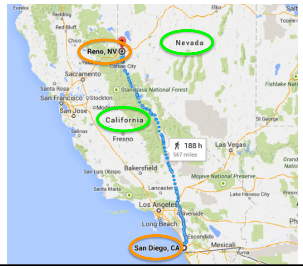
## Survey knowledge

## 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

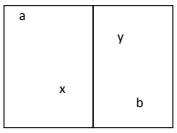
- **Superordinate:** Nevada is east of California
- **Subordinate:** BUT Reno isn't east of LA




## Spatial hierarchies

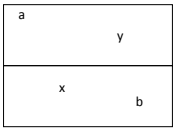
- Stevens & Coupe (1978):
  - Learn map; then "Is x east of y?"

*Propositional that complements analog?*




Subordinate: E/W
Superordinate: E/W

*Faster to judge*




Subordinate: E/W
Superordinate: N/S

*Slower 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? 

- 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!

## Do we "need" imagery?

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

## 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

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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

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    - 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

## Are visual images really 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

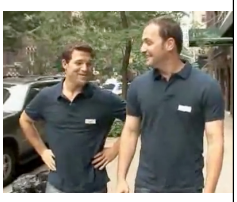
## Visual details

- 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
      - Omitted 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]

## Picture memory

- Uncannily good.
- Shepard (1967)
- 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

## Picture memory

- Paivio (1971) *dual coding hypothesis*
  - Verbal code (kinda like propositional)
  - Imaginal code (kinda like analog)
  - Pictures have both, words have only one
- 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

- Goldinger (1998): talker-specific priming
  - 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?

## Auditory memory

- 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

## Auditory memory

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

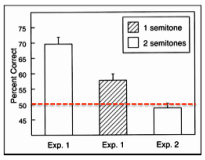


Fig. 1. Performance on excerpts pitch-shifted by 1 or 2 semitones (chance = 50%). The excerpts were familiar in Experiment 1 and unfamiliar in Experiment 2. Error bars represent standard errors.

## Auditory memory


- 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**

## Auditory memory

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