Memory for Multidimensional Stimuli

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Research Objectives

• Computational model of the architecture of spatial cognition
• Embedded in ACT-R as a spatial module
• Methodology:
  – Focus on screen-based tasks
  – Bottom-up approach
    • Spatial attention [Hongbin’s talk]
    • Visual objects, features, locations [This talk and Cog Sci]
    • Object-to-object relationships [Cog Sci poster]
    • Map tasks: Screen based objects and relations as representations of objects around you
Evidence for Independent Encoding of Object Features: Illusory Conjunctions

- Typically brief presentation time (50-120ms) with mask
  - See: □ ⬤
  - Report: blue circle

- May be due to
  - Misperception
  - Binding errors
  - Error in recombining features from memory
Evidence for Independent Encoding:
Memory Conjunction Errors

- Longer presentation times, no mask
  - Stefurak and Boynton (1986)
  - 5 colored forms for 5 seconds, no mask
  - 1 old or new target
  - Controlled for verbalization using mental arithmetic task
  - Found complete independence of color and shape
The Role of Spatial Location in Feature Integration

• Johnston and Pashler (1990)
  – Found no perception of object features without the perception of object location
  – but object location was known on 10% of the trials in which the feature was not known.
Nissen Task (1985)

- **Stimuli:**
  - 4 shapes
  - 4 colors
  - 4 locations
- **Duration 60-190 ms**
- **Mask**
- **Replaced with cue:**
  - **Conditions:**
    - Color cue
    - Location cue
Nissen Results

• Location cue
  – Correct recall of color and shape is statistically independent

• Color cue
  – Correct recall of shape is statistically dependent on recall of location

• Nissen argued that features were stored independently, but tagged or indexed by location
ACT-R/PM Predicts Dependence

• ACT-R/PM produces an integrated representation

• Predicts complete dependence of color and shape given location
ACT-R Model of Nissen Task

• Given correct representation Act-R can model data
Given Location Cue

Independent Retrieval of Color and Shape
Given Color Cue

Shape Depends on Retrieval of Location
Evidence for Integrated Feature Repr.

• Luck and Vogel (1997)
  – Visual working memory retains up to 4 objects where each consists of a conjunction of 4 features

• Monheit and Johnston (1994)
  – Found dependence of color and shape
    • Used the Nissen task with two extra colors to reduce the effects of guessing
    • Used 288 trials instead of 64
Modified ACT-R 5.0
Preattentive Objects

• Spatially tagged features placed in declarative memory
Attended Objects

- Attention adds associations among features
Implications for ACT-R

• ACT-R can model tasks with very brief presentation times
• Can model conjunction errors
  – Illusory conjunctions
  – Memory conjunction errors
• Can model recoding effects
  – Ex: Recode visual as verbal
    • “red triangle, blue square, etc.”
• Positional encoding of visual features is similar to positional encoding of list memory
  – Could positional encoding be the result of perception?
Future Plans

• Features tagged by object
  – Object-based attention and visual search results suggest that features are tagged by the object that owns them
    • Object with features red, blue, vertical line, horizontal line
      • Attention is required to determine the relationships between the features
        – Red vertical line, blue horizontal line

• Temporal tags
• Visual indexes