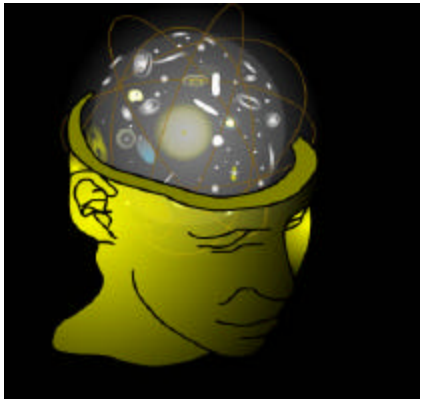


Memory for Multidimensional Stimuli

Todd R. Johnson,

Hongbin Wang,

Jiajie Zhang,

Yue Wang

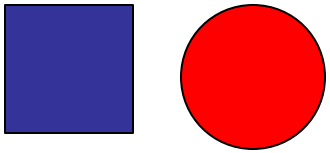
University of Texas Health Science Center at Houston

School of Health Information Sciences

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

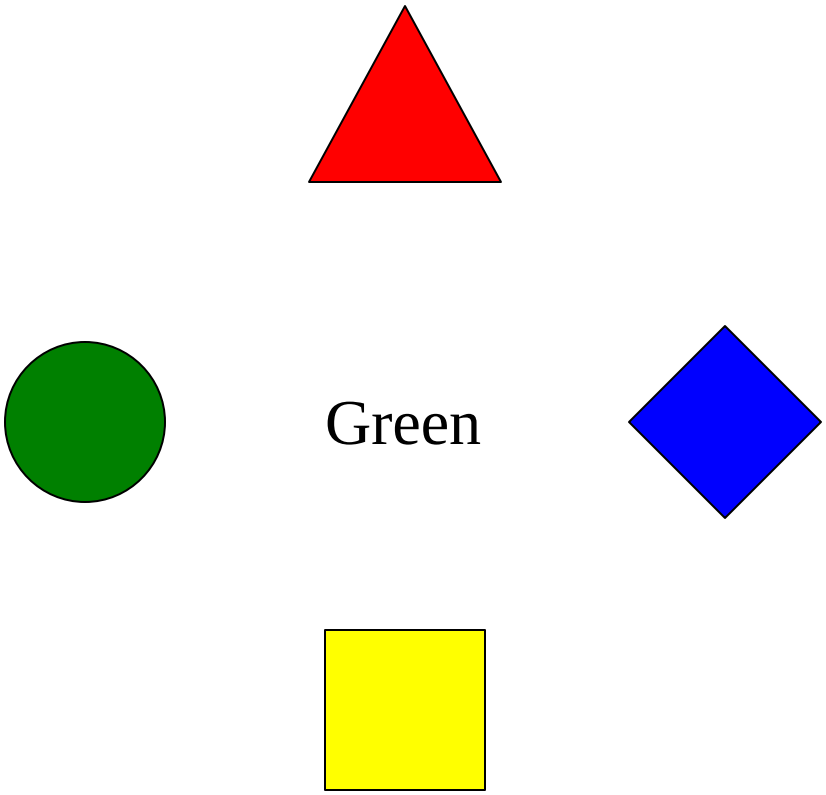
- Longer presentation times, no mask
  - Stefurak and Boynton (1986)
  - 5 colored forms for 5 seconds, no mask
  - 1 old or new target
  - Controlled for verbalization using mental arithmetic task
  - Found complete independence of color and shape

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

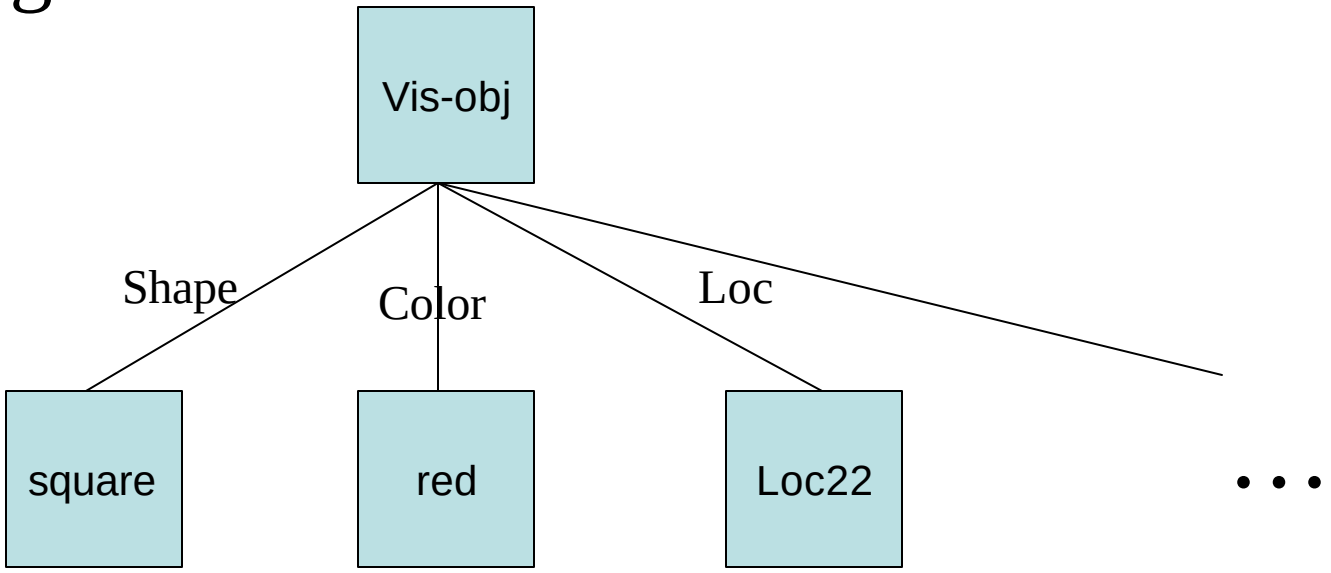


Nissen Results

- 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



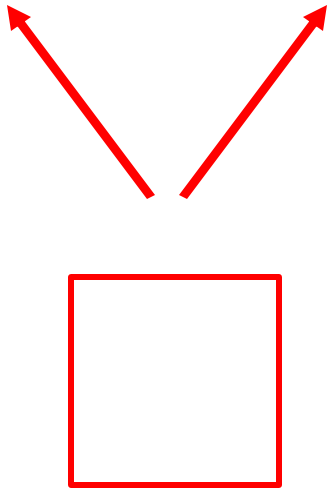
ACT-R Model of Nissen Task

See Cog Sci 2002 Conf. Paper

- Given correct representation Act-R can model data

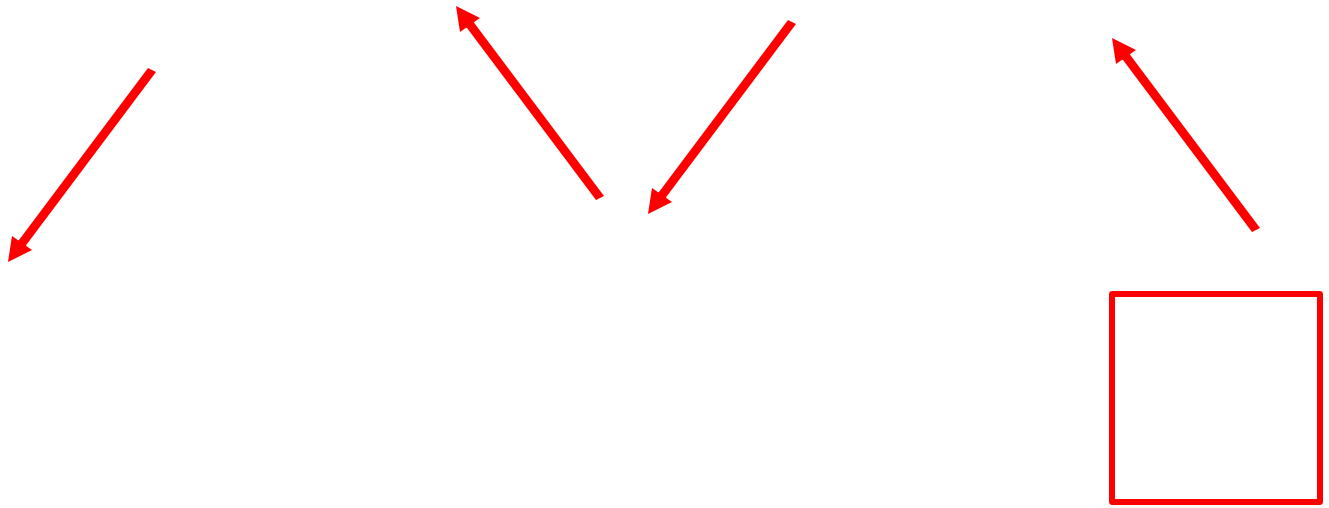
Given Location Cue

Independent Retrieval of Color and Shape



Given Color Cue

Shape Depends on Retrieval of Location



Evidence for Integrated Feature Repr.

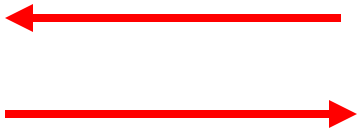
- Luck and Vogel (1997)
  - Visual working memory retains up to 4 objects where each consists of a conjunction of 4 features
- Monheit and Johnston (1994)
  - Found dependence of color and shape
    - Used the Nissen task with two extra colors to reduce the effects of guessing
    - Used 288 trials instead of 64

Modified ACT-R 5.0 Preattentive Objects

- Spatially tagged features placed in declarative memory

Attended Objects

- Attention adds associations among features

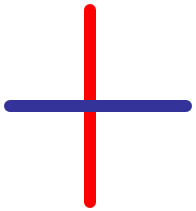


Implications for ACT-R

- 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