



# In the Glimpse of an Eye: Decision Making and Vision

Diana Eugenie Kornbrot  
Psychology Department  
University of Hertfordshire



# Outline: Vision & Decision Making

---

## # Visual search has no memory?

- Key Search Task by Wolfe & Horowitz
- Key Empirical Findings

## # Psychophysical Model

- Information Accrual Model
- Includes Decision Making
- Models errors and reaction time

# The Search Task

## # Letter Display on Screen

- Refreshed every 111 msec
- Contains either E or N among other letters
- Participant response with 'E' or 'N' key press

## # Display Types

- Static: letter arrangement same on each presentation
- Random: letters randomly rearranged for each presentation

## # Visual Attention Lab at Harvard

- <http://search.bwh.harvard.edu/>
- Beautiful work on early visual processes
- Striking and important results, although I disagree with *one* conclusion



# The Search Task: Demo

---



# Manipulated Variables

---

## # Display type:

- Static or Random

## # Set Size

- 8, 12, 16 letters in display, including E or N

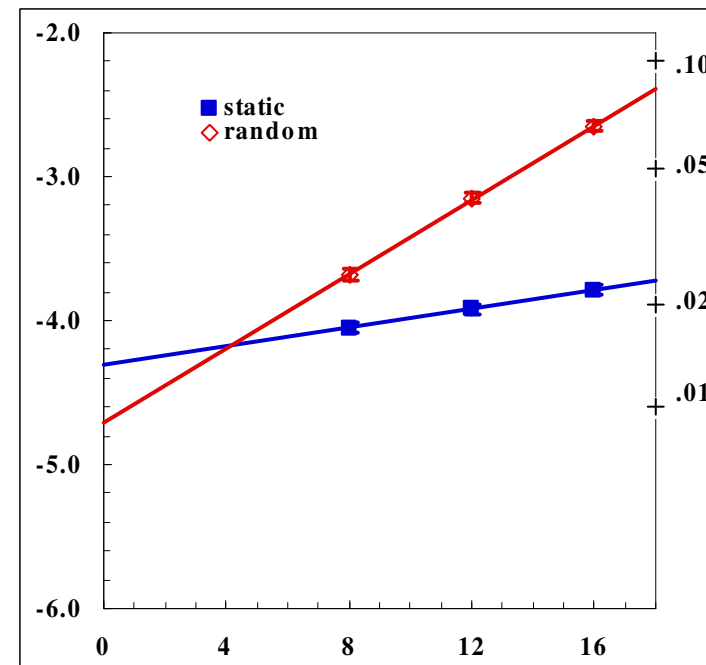
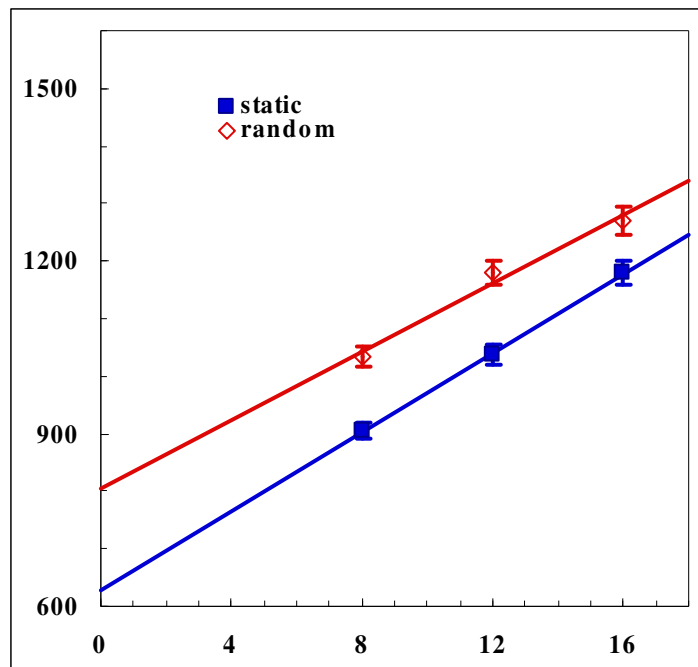
## # Eccentricity

- Location of target relative to centre
- On 'ring' 0, 1, 2, or 3

# Design and Measures

- # All participants performed in all conditions
  - Repeated measures design
  - 11 participants
- # 480 Trials per condition
- # Measures taken on each trial
  - 1: Reaction Time in msec
  - 2: Response is correct or error

# Results: Effect of Set Size



■ Reaction Time: Msec

■ Errors: logit left, prob right

# Results: Display Type

## # Reaction Time

■ Static:  $t = 624 + 34.7s$

■ Random:  $t = 806 + 29.6s$

■ Slope: random-static = 5.1 msec/item  $p = .1103$

■ Intercept : random-static = 188 msec  $p = .0015$

## # Logit Error

■ Static:  $lgt = -4.31 + .03s$

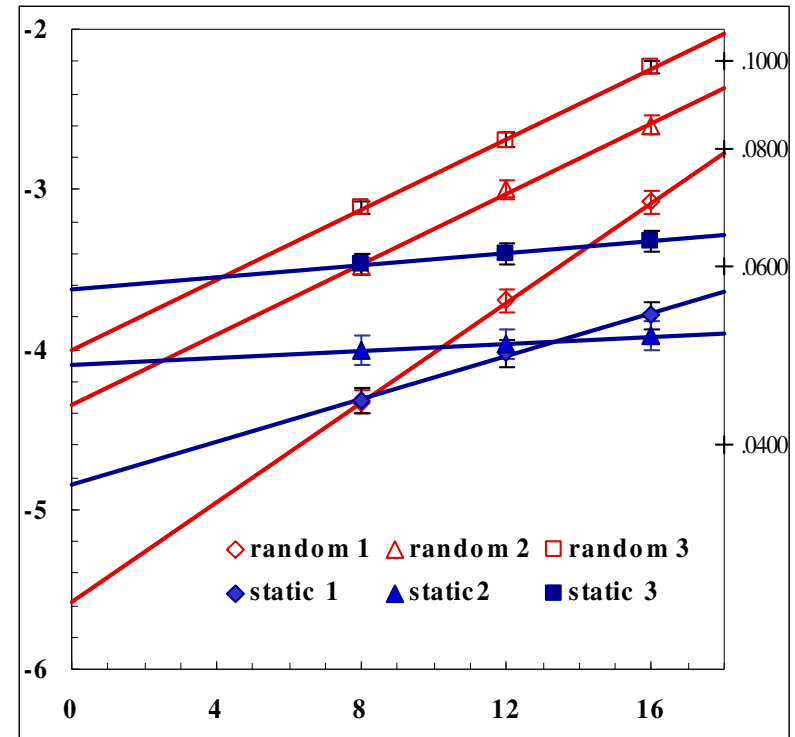
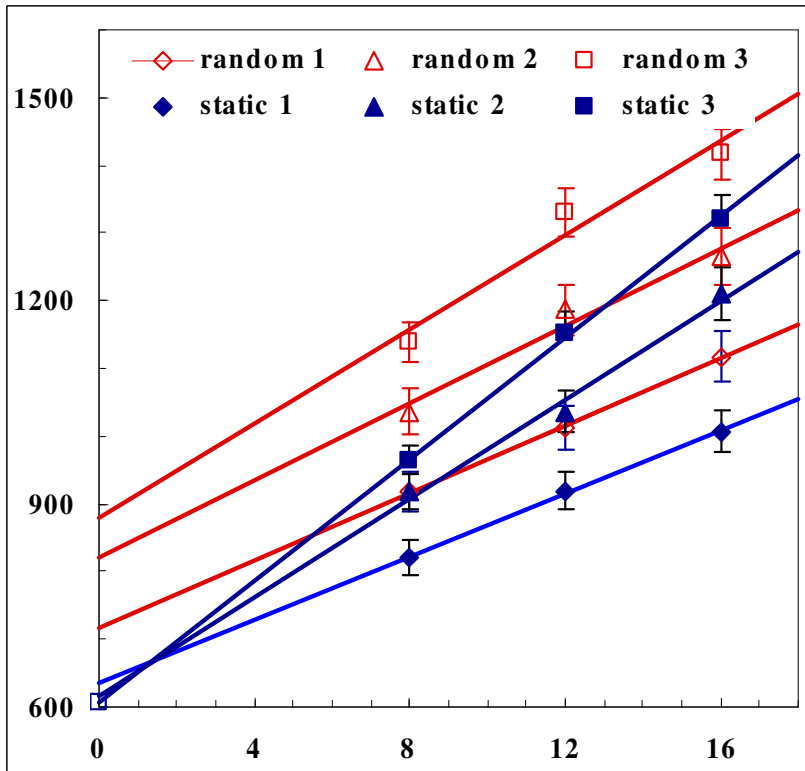
■ Random:  $lgt = -4.71 + .13s$

■ Slope: random-static = +.13 /item  $p = .0042$

■ Intercept: random-static = +.04  $p = .3197$



# Results: Effect of Set Size & Eccentricity



■ Reaction Time: Msec

■ Errors: logit left, prob right

# Results: Display and Eccentricity

- # Reaction Time Slopes: All increase with set size
  - Static: Increases with eccentricity
  - Random: No effect
- # Reaction Time Intercepts
  - Static: No effect
  - Random: Increases with eccentricity
- # Errors as measured by  $\text{logit}(p(\text{error}))$  Slopes
  - Static: No effect, flat with sets size
  - Random: Increases with eccentricity
- # Errors as measured by  $\text{logit}(p(\text{error}))$  Intercepts
  - Static: Increases with eccentricity
  - Random: Increases with eccentricity

# Summary

---

- # There is whacking effect of display on memory
  - Random 188 msec slower
  - Errors higher for random
  - Random, only, shows effect of set size on errors
- # RT Intercepts matter
  - Similarity to classic present-absent effects
- # Errors Matter
  - Different pattern to RTs
  - Need logistic regression

# Problems for Theory of Visual Search

- # RT slopes can be lower for random than static presentations
- # RT intercepts are always higher for random than static presentations
- # Error rates are independent of set size for static presentation
- # Error rates increase with set size for random presentations only

# A Model for Visual Search

## # Information Accrual

- Observers accumulate information for each of two possible responses in location independent accumulators, by a process such as a random walk.
- The rate of information accumulation is inversely related to set size,  $s$ .
- Consequently the time needed to achieve a fixed criterion,  $C$ , will be  $C*s$ , giving the standard linear RT versus set size function.

## # Decision Criteria

- People set a criterion for each response, and make whichever response first reaches criterion.

# Decision Heuristic 1: Maintain Accuracy

- Increase criteria by amount  $S_V$  proportional to set size
  - Causes an RT *slope* increase of  $S_V$
- BUT more distractors may ALSO mean more ‘noise’
  - So greater increase in criterion for distractors.
  - Causes higher *slopes* when targets are absent
    - Often observed, but absent not necessarily 2\* present slopes
- Set size *dependent* increases in criteria *may* cause set size *independent* error rates.
- Increases in decision criteria for more difficult tasks, slower information accrual, may not be able to maintain accuracy
  - So speed and accuracy *may* decline together.

## Decision Heuristic 2: Fixed Criterion Increase

- # : Increase criterion by  $I_v$ , independent of set size.
  - Causes an RT *intercept* change of  $I_v$ .
  - Occurs when there is loss of information over time,
    - Masking
    - Random relocation of targets
- # Leads to fixed, set size independent, increase in RT, that is an increase in *intercept*

# Speed-Accuracy Trade-Offs

- # Perfect accuracy rare
  - Loss of information with time
- # Semi-voluntary
  - 'Neutral' trade-off depends on task difficult
  - Law of diminishing returns
- # Voluntary control within limits
- # Model in terms of  $S_v$ ,  $I_v$ 
  - $S_v$  set size dependent criteria
  - $I_v$  set size independent criteria



# Actual Decisions

- # Compromise between Heuristics
- # Heuristic 1: Set size dependent criteria  $S_v$ 
  - RT linear with set size
  - Errors set size independent, if successful
- # Heuristic 2: Set size independent criteria  $I_v$ 
  - RT intercept changes
  - Errors *increase* with set size

# Ultimate Modelling Goals

---

- # Decision Parameters from Empirical Data
  - Reaction Time Summaries, Error Rates
  - Mean, Variance, Skew, Kurtosis
- # Modelling Goals?
  - Not there yet!
  - Closed form solutions not possible
  - Will need simulation

# Final Summary

---

- # Visual Search DOES have a memory
- # Need RT *intercept* as well as *slopes*
- # Need to model *errors* as well as RTs
  - Logistic Regression is Key Tool for Errors
- # Modelling must include Decision Criteria
  - General approach promising
  - The devil is in the detail

# Final Glimpse



20-Oct-04

Fechner 2004. In the Glimps of an Eye Kornbrot© University of Hertfordshire, UK