

# ATTENTION

9.00-10.00 Jan Theeuwes, VU  
Spatial Selective Attention: An Introduction  
10.15-11.15 Dirk Heslenfeld, VU  
Functional Brain Imaging of Attentional Processes  
11.30-12.30 Pieter Roelfsema, UvA  
Attention and the Visual Cortex

# Overview

- What is attention?
  - models (early vs late)
- Visual search
  - pre-attentive/ attentive processing
  - top-down vs bottom-up control

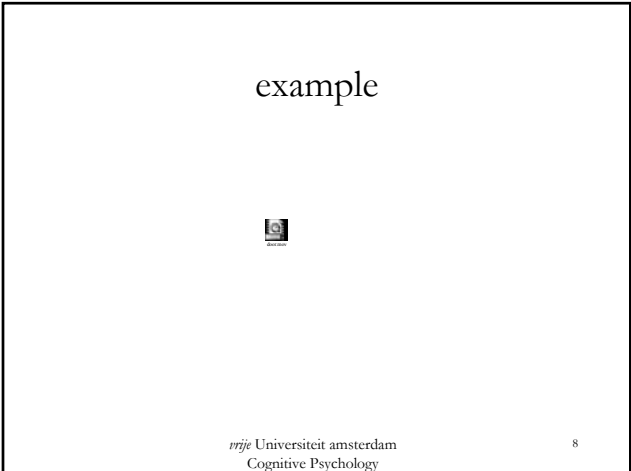
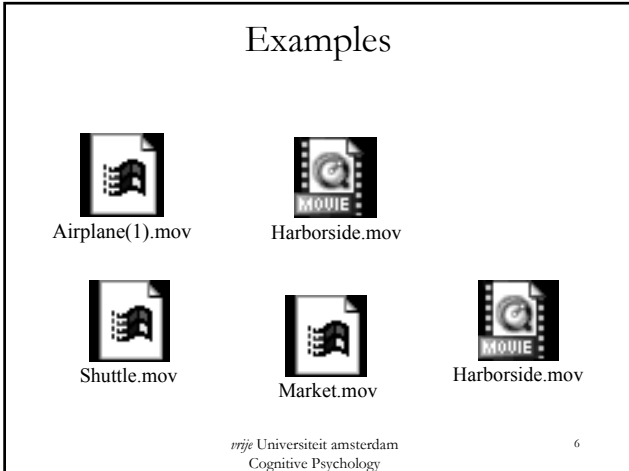
## Spatial Selective Attention An Introduction

Jan Theeuwes

*Vrije Universiteit, Amsterdam*

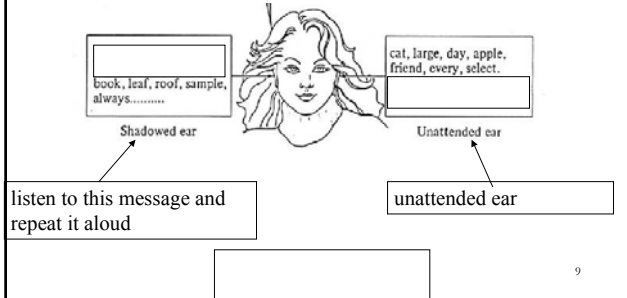
## what is attention?

- you only see what you attend
- attention determines which information is processed and which information is 'ignored'



## dichotic listening

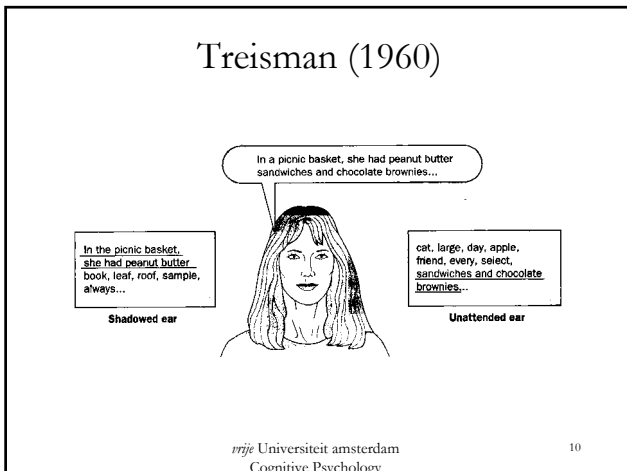
- Cherry (1953): shadowing of either message (directing attention to information presented in one ear)



## MODELS

- early selection theory (Broadbent, 1958)
  - filter theory
- late selection theory (Deutsch & Deutsch, 1963)
- attenuation theory (Treisman, 1960) “verzwakking”

## Treisman (1960)





## What is attention?

- Directing attention to a location in space
  - metaphor: directing the spotlight of attention
  - experiments: cueing (Posner's cueing tasks)
    - exogenous (bottom-up)
    - endogenous (top-down)

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## What is attention?

- Attention is spatial

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### Stimulus Sequence from an Endogenous Cueing Experiment

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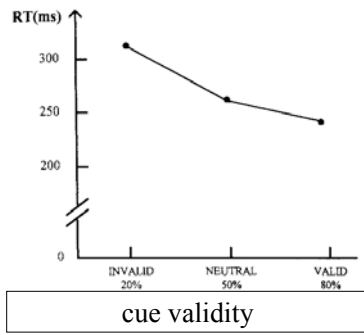
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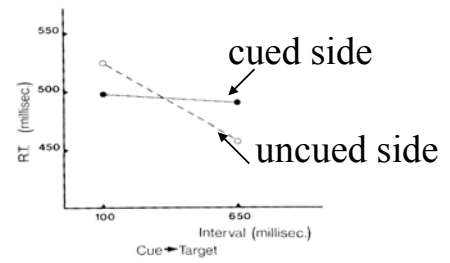
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## Endogenous cueing



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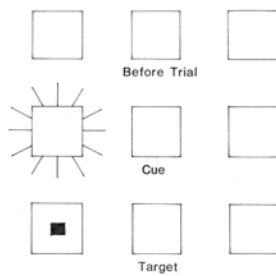
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## Exogenous cueing



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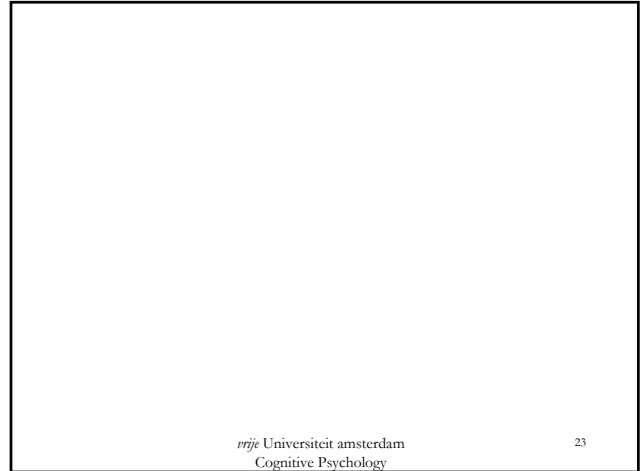
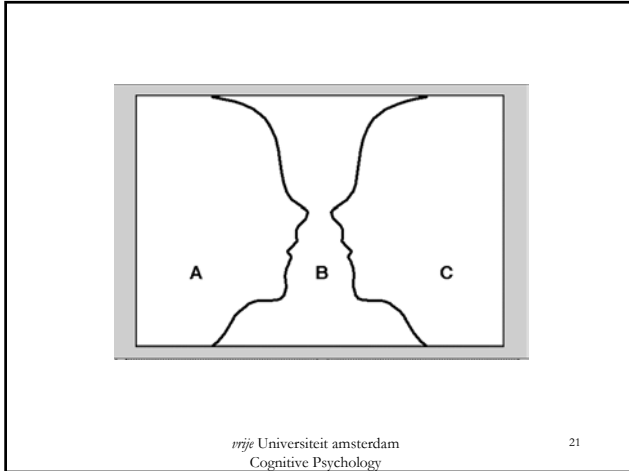
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## What is attention?

- Attention can be object based
  - attention travels along an object

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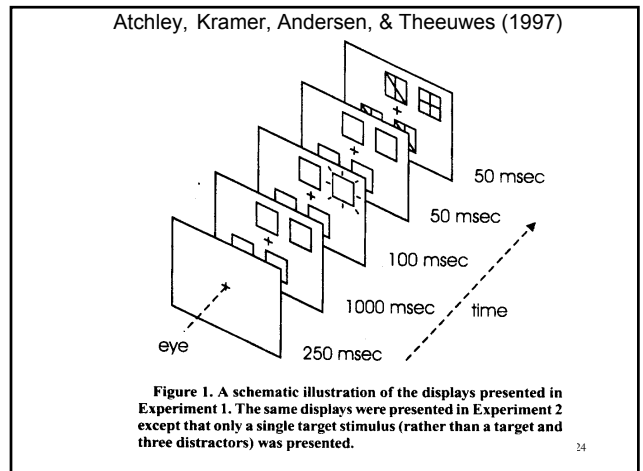


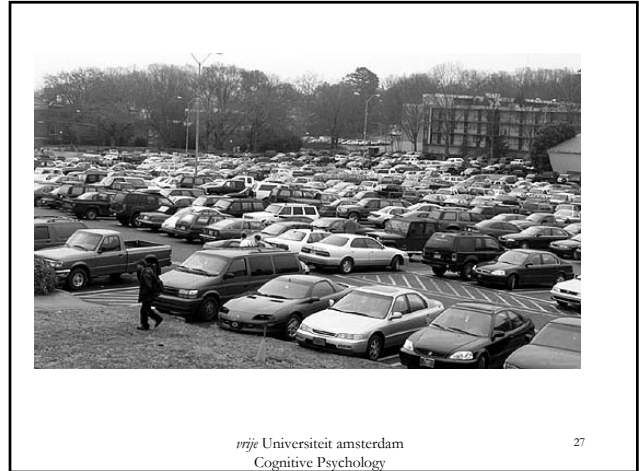
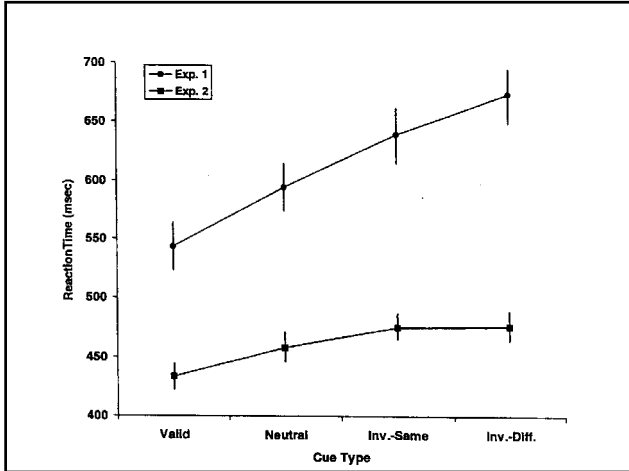
## What is attention?

- Attention can be allocated in 3D
  - selection occurs after 3D representations have been derived from the 2D input

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## Deploying Visual Attention The Visual Search Paradigm

- How do we search our environment?

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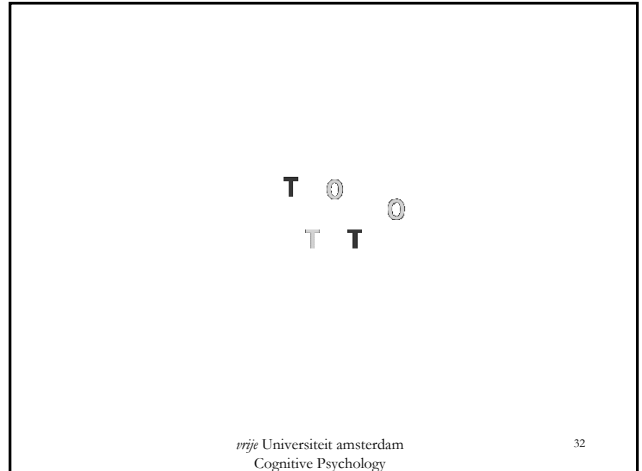
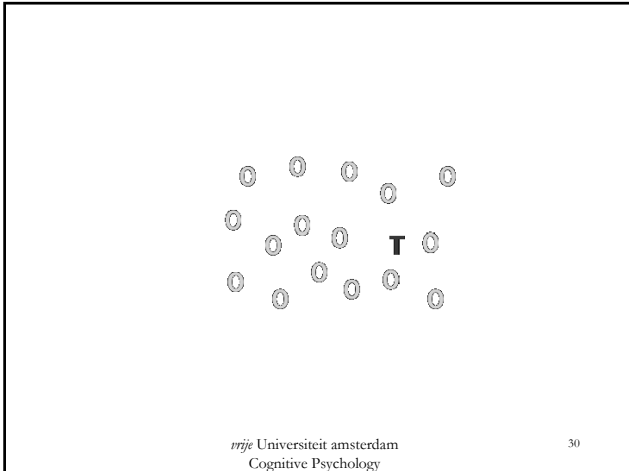
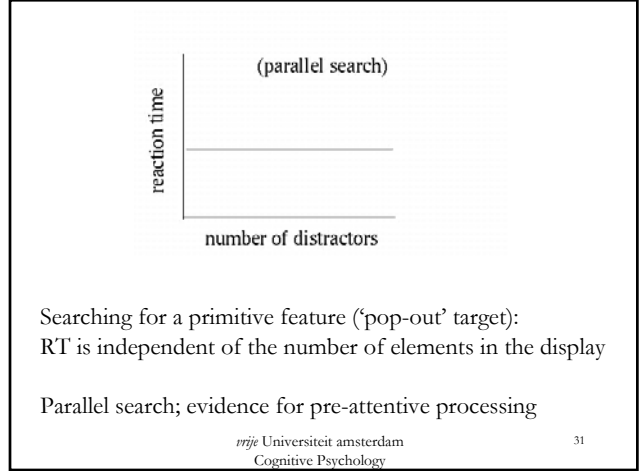
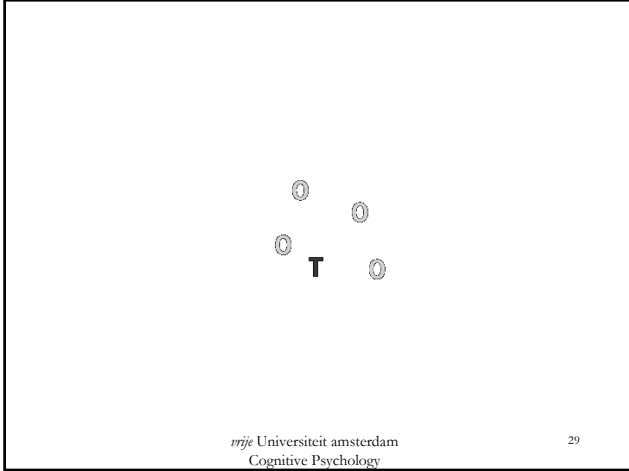
## Deploying Visual Attention The Visual Search Paradigm

- Feature integration theory Treisman
  - Treisman & Gelade (1980)

Searching for a T

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Dependent variable: time to find the target  
 “serial” search: slope target absent (red) twice as large as the slope for target present  
 “parallel” search: flat search function; no difference between present and absent

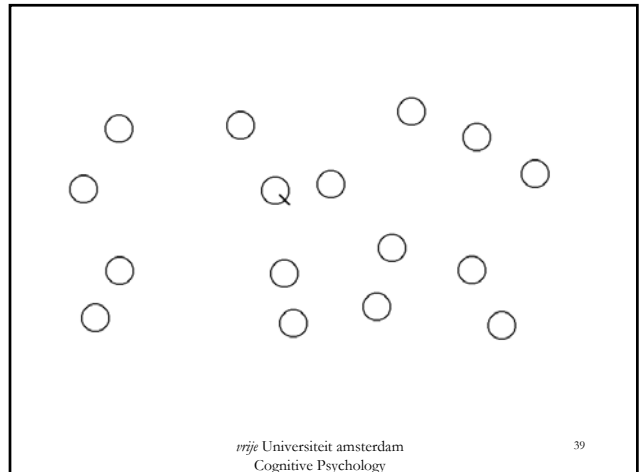
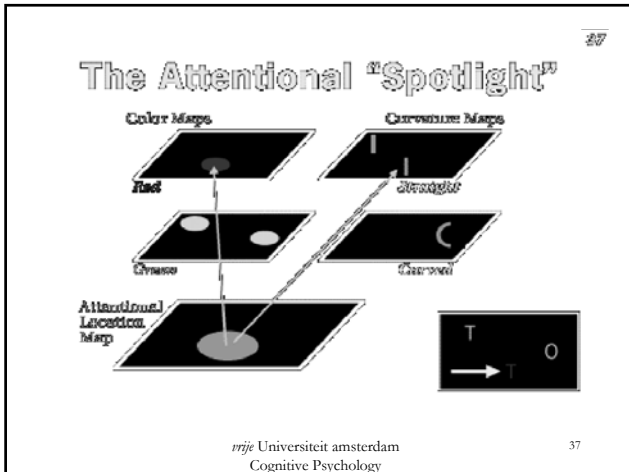
• Search for a conjunction target:  
 Search time increases with the number of elements in the display (serial search)  
 “attentive processing” (attention is necessary)  
 • what about present-absent RTs?

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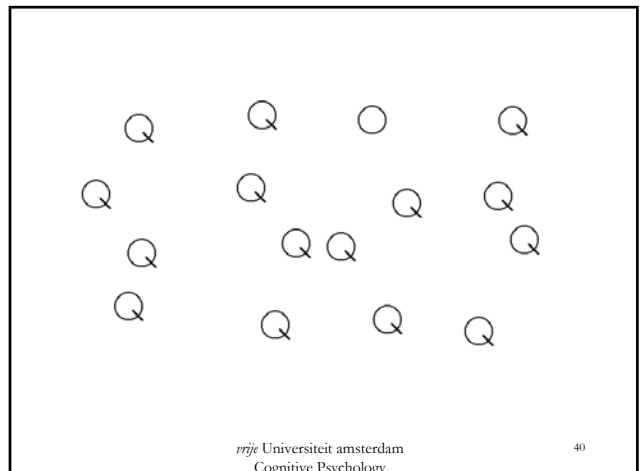
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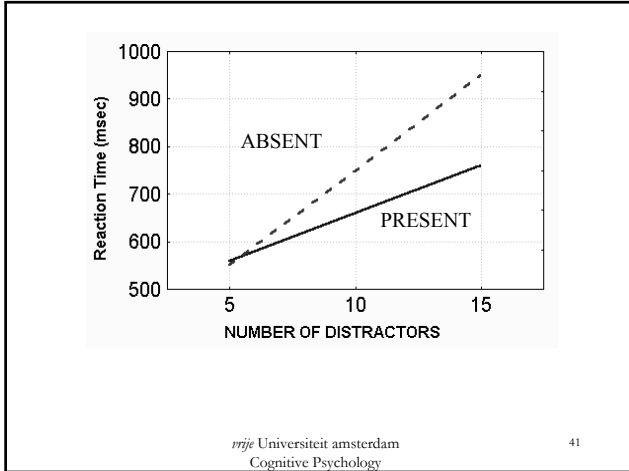


### Pop-Out

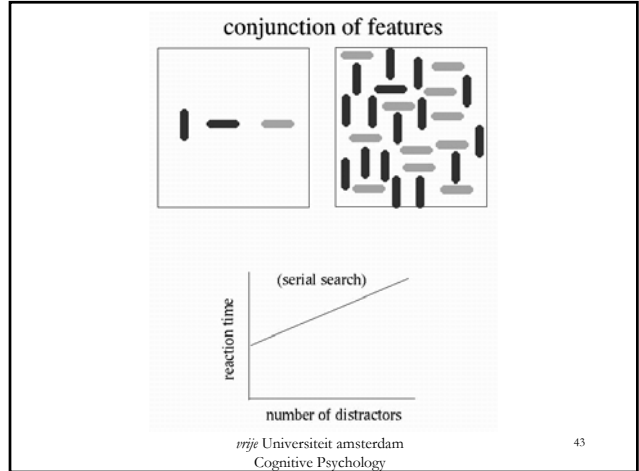
- Hypothesis: Simple features pop out because they generate unique activity on a feature map
- Prediction: Absence of feature should not pop out
  - target O
  - Distractors Q

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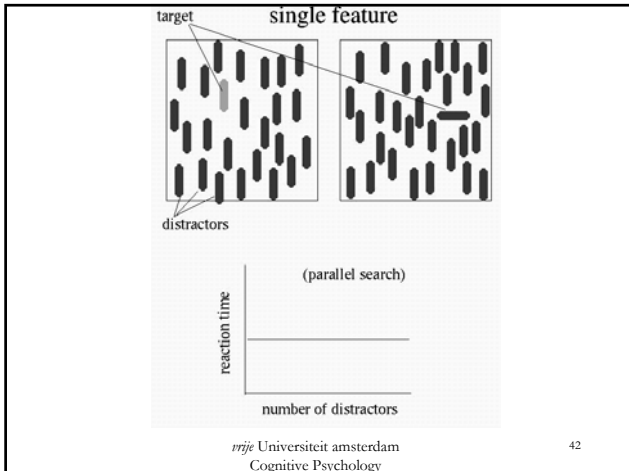




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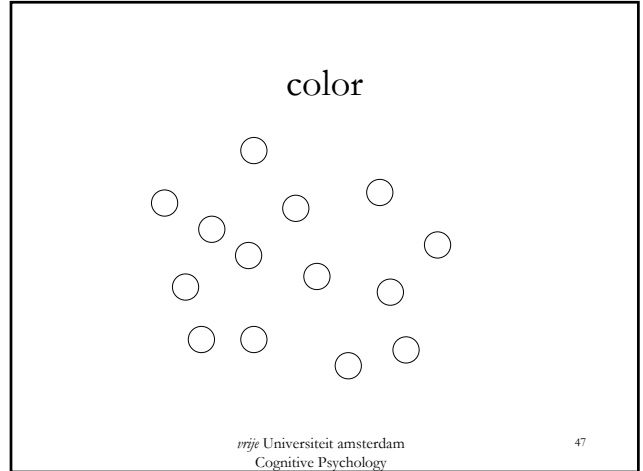
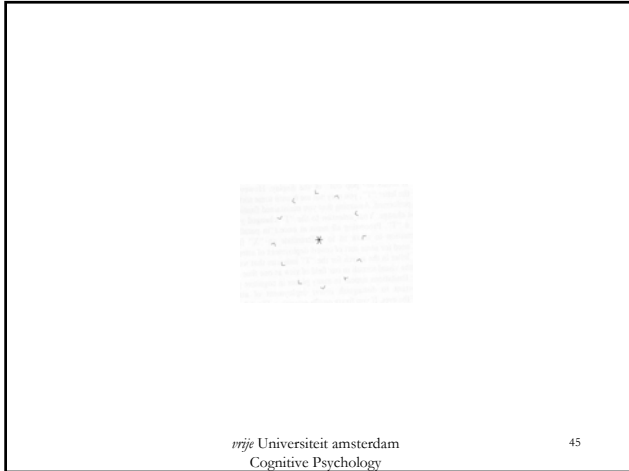
## Visual Search

The search paradigm

Note: (1) covert deployment of attention (no eye movements!)  
(2) high acuity should not be necessary to detect the target

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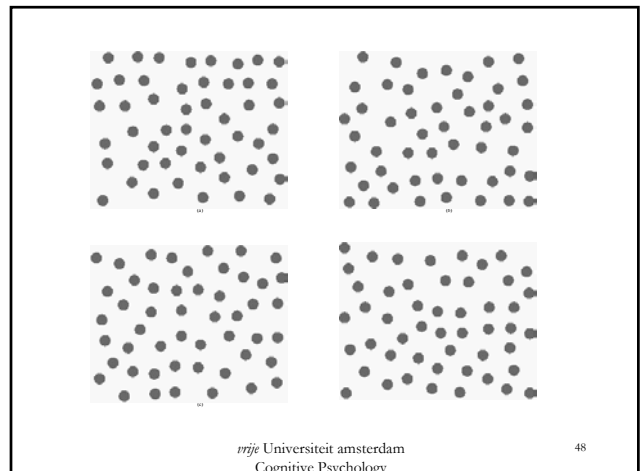


## Visual Search

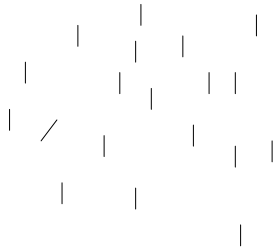
- Basic features can be detected by pre-attentive processing
- If a feature pops-out it implies that there are specialized modules that allow the detection of these basic feature
- The classic two-process theory (e.g., Broadbent, 1958):
  - two independent, sequential stages:
  - first stage: preattentive processing (parallel)
  - second stage: attentive processing (serial)

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## orientation

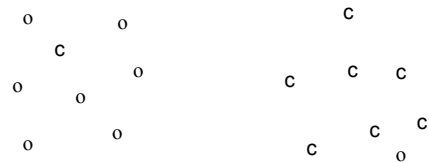


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## Shape

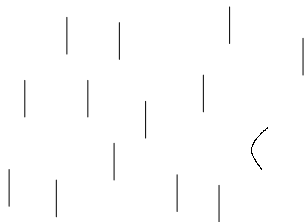
Line termination as a basic feature



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## curvature

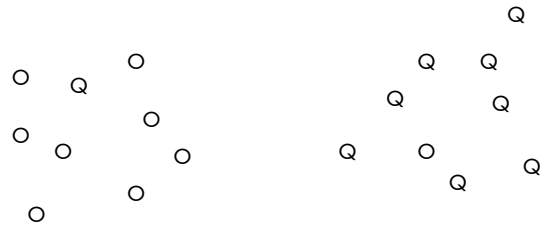


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## Q between O

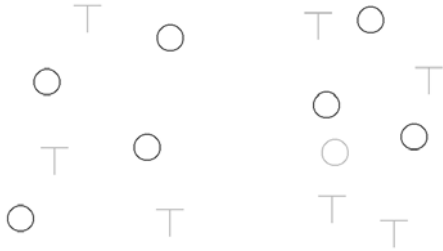
the coding of the absence of a feature



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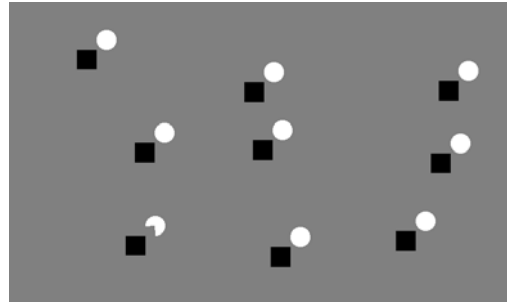
### Conjunction search



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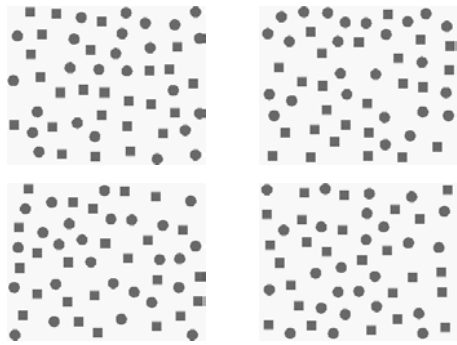
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### Circle Completion



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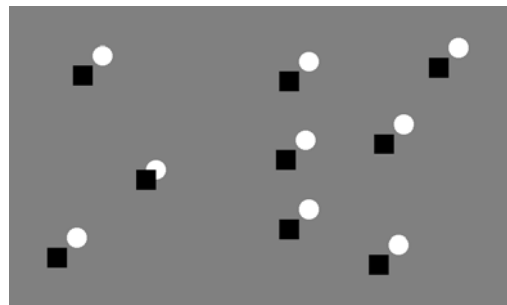
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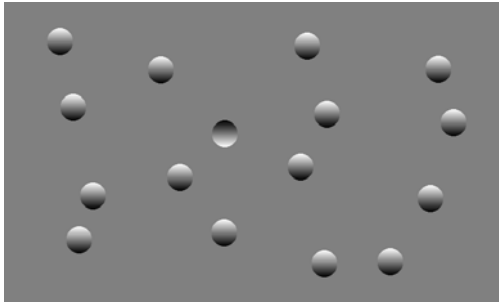
### Circle Completion



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## Shade

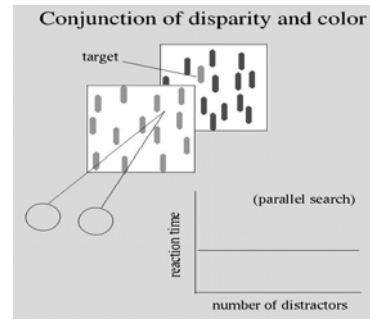


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## Conjunction search

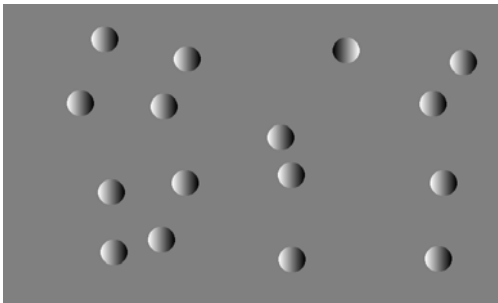
Directing attention to a particular plane (Nakayama & Silverman, 1986)



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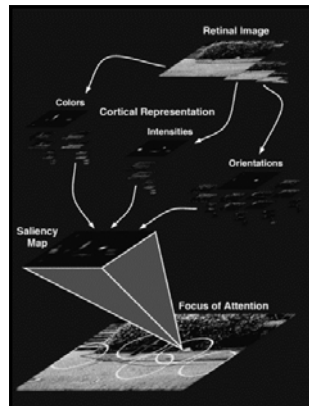
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## Shade



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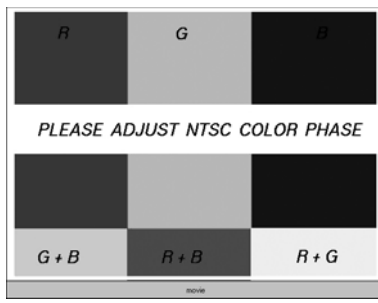


L. Itti, C. Koch, E. Niebur  
(1998)  
A Model of Saliency-Based Visual  
Attention for Rapid Scene Analysis, *IEEE*,  
20, 11, pp.1254

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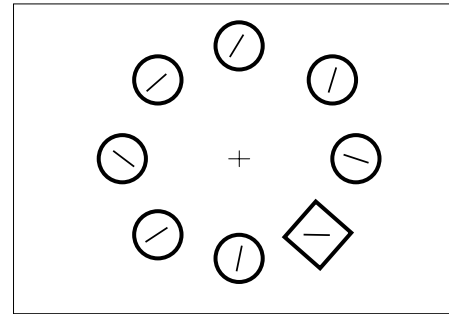
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## Demo



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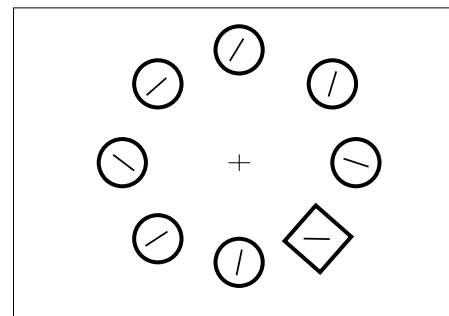
Theeuwes, 1992

## Top-down and bottom-up control in visual search

- Top-down view:
  - It is possible to select only information relevant for the task at hand
- Bottom-up view:
  - Particular stimulus features force to be selected (we cannot help selecting them)

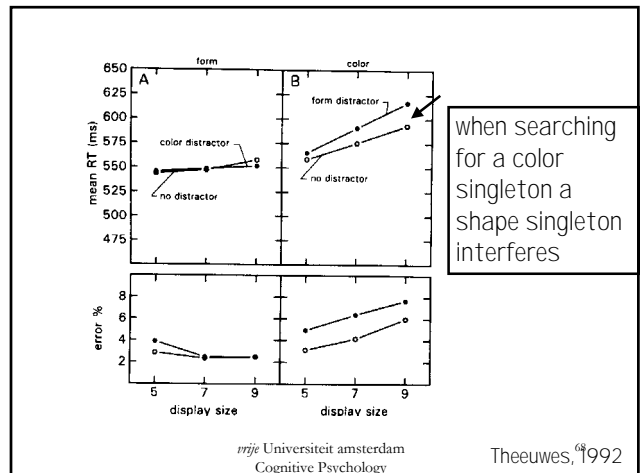
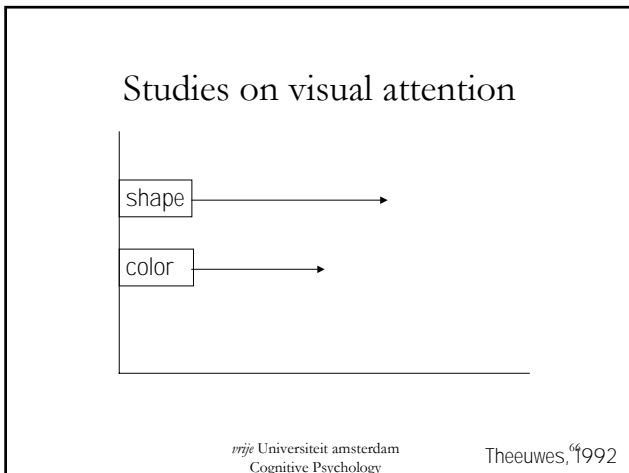
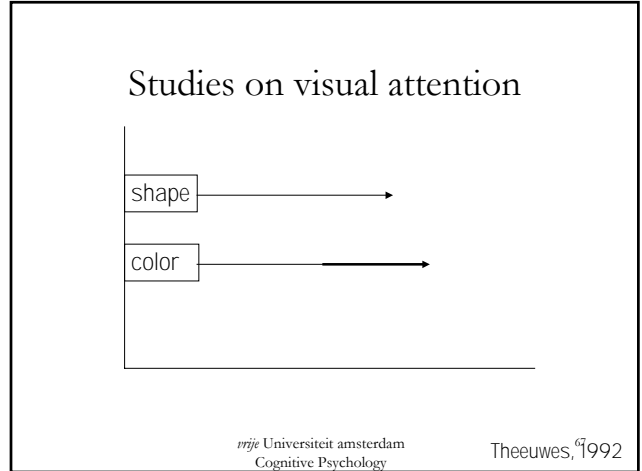
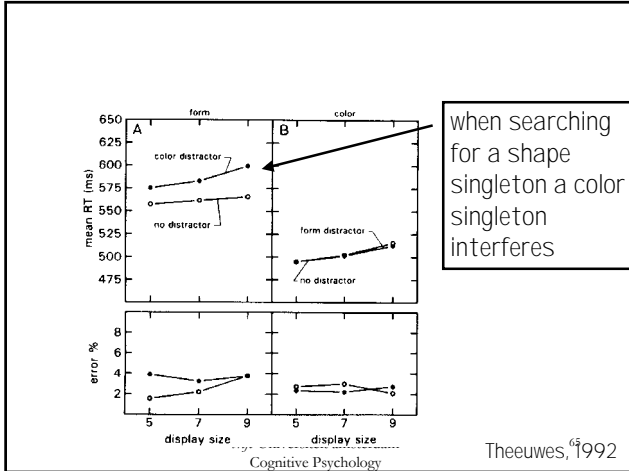
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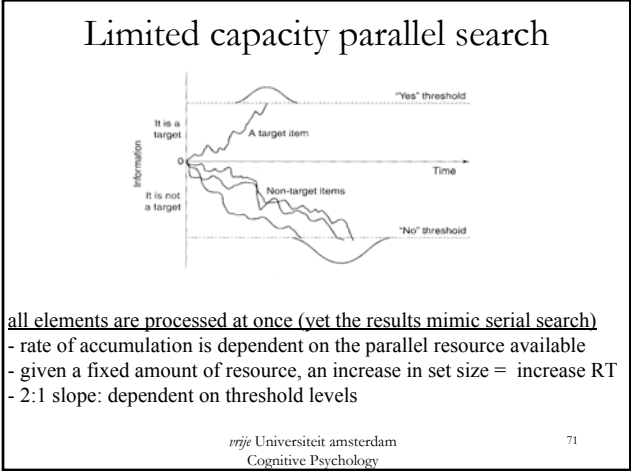
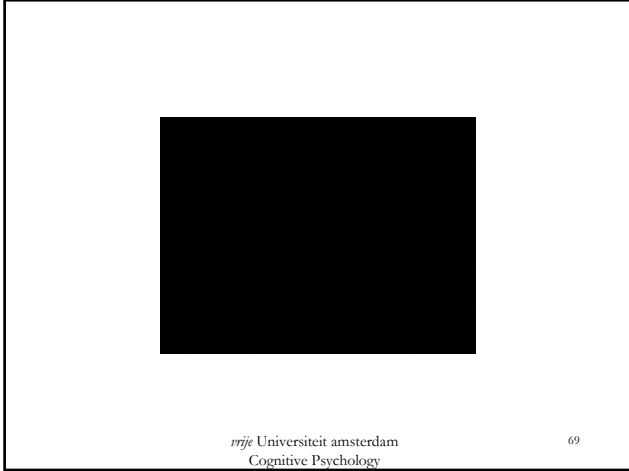
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Theeuwes, 1992



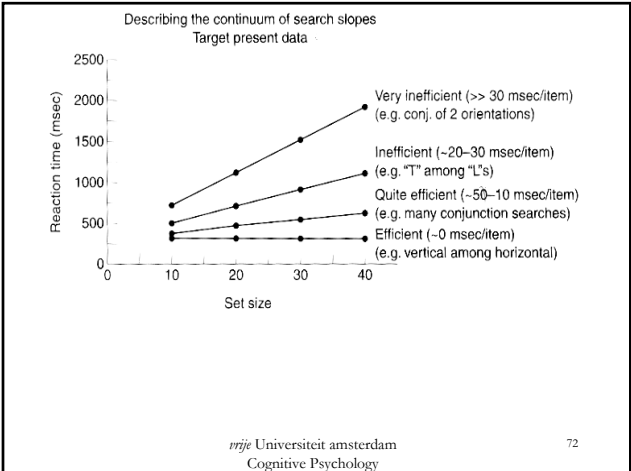


### parallel vs serial search

The strict dichotomy between  
 parallel and serial  
 preattentive and attentive  
 is useful yet it may be necessary to reformulate

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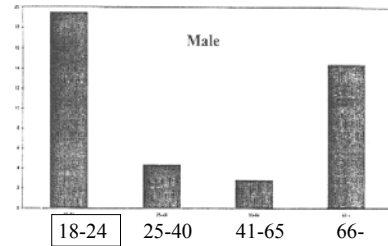
## The role of Attention

- Attention to a particular location is needed to conjoin features

- Prediction: if the "spotlight" is widened, you will sometimes misconjoin features, leading to illusory conjunctions

X O Ss may report a green X or a red O  
Shape and color are not well conjoined

## People killed in traffic



Car drivers killed per 10<sup>6</sup> km  
NL 1992-1994

## Useful field of view (UFOV)

