Multisensory perception

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Outline

1. From sensation to perception
2. Attention
3. Spatial perception
4. Multisensory interactions
5. Sensory substitution

Definition of attention

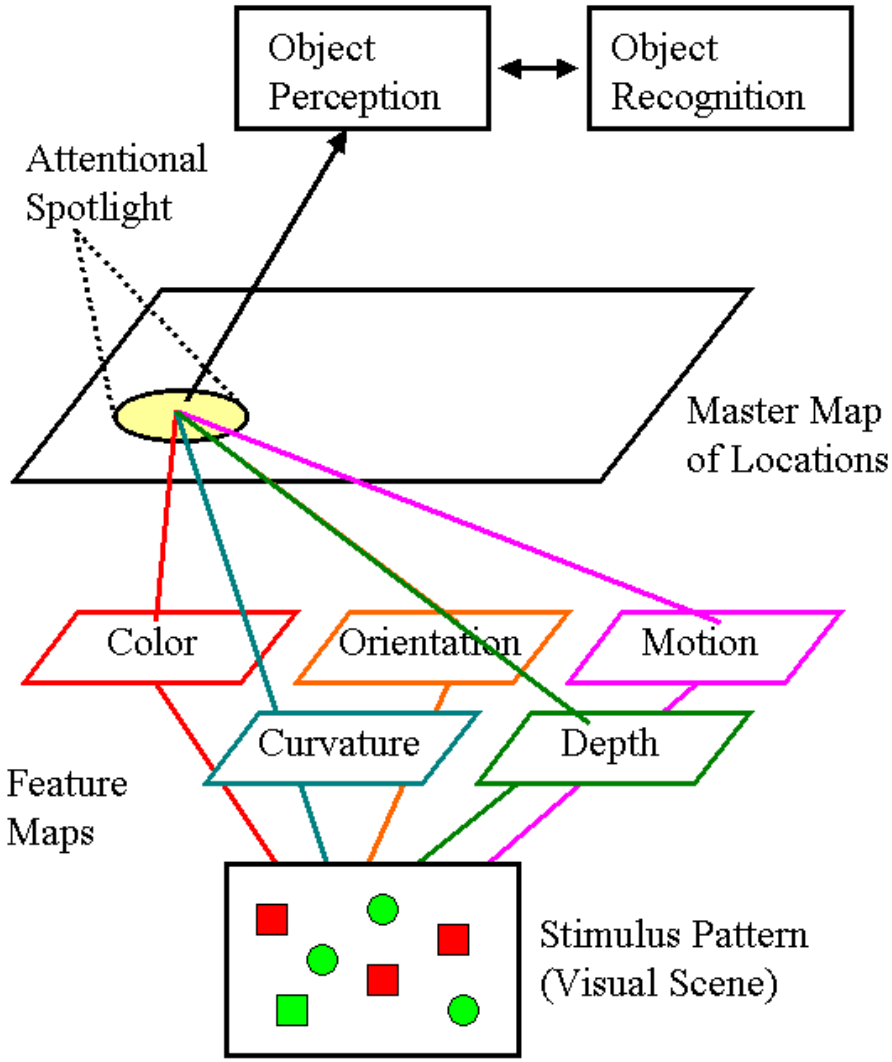
« Activity or state by which a person increases its efficiency with respect to some psychological contents (e.g., perceptual, intellectual, from memory), most of the time by selecting some parts or some aspects and by inhibiting or neglecting others »

Larousse dictionary

Our brain is always making choices: attention refers to this process of choices

Definition of attention

- Perceptual binding: theory of traits integration



Treisman & Gelade, 1990

Demonstration

Identify the black numbers

2 X O T 4

Demonstration

Describe the colors and shapes of central elements

2 X O T 4

Demonstration

- Presentation 200-400 ms

  2 X O T 4

- Task:
  - Identify the black numbers
  - Describe the colors and shapes of central elements

- Illusory conjonction in 30% of cases (e.g. green T)

Treisman & Schmidt, 1982

Definition of attention

- Perceptual binding: theory of traits integration

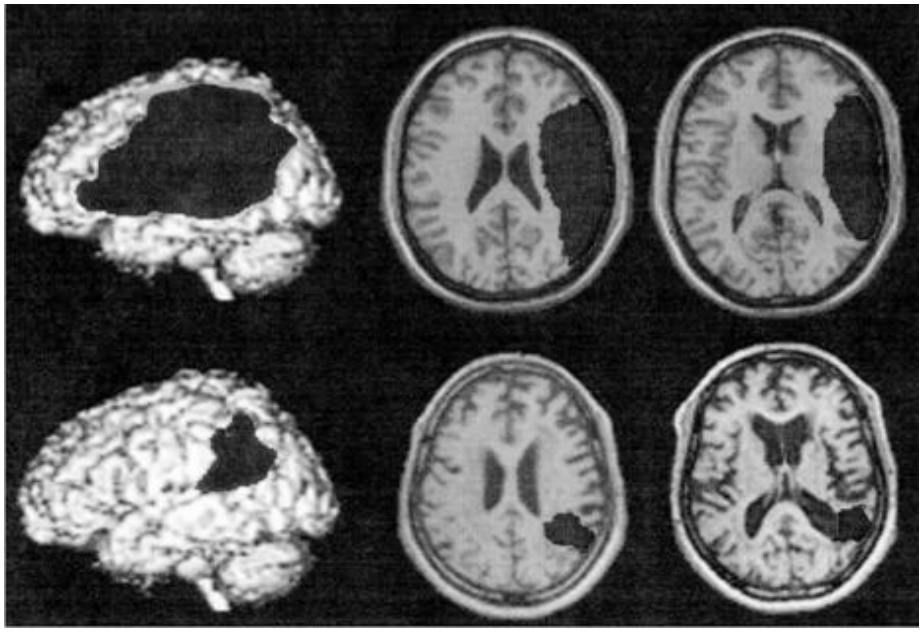
- Selective filtering: ability to facilitate one type of information (focus) while ignoring another type

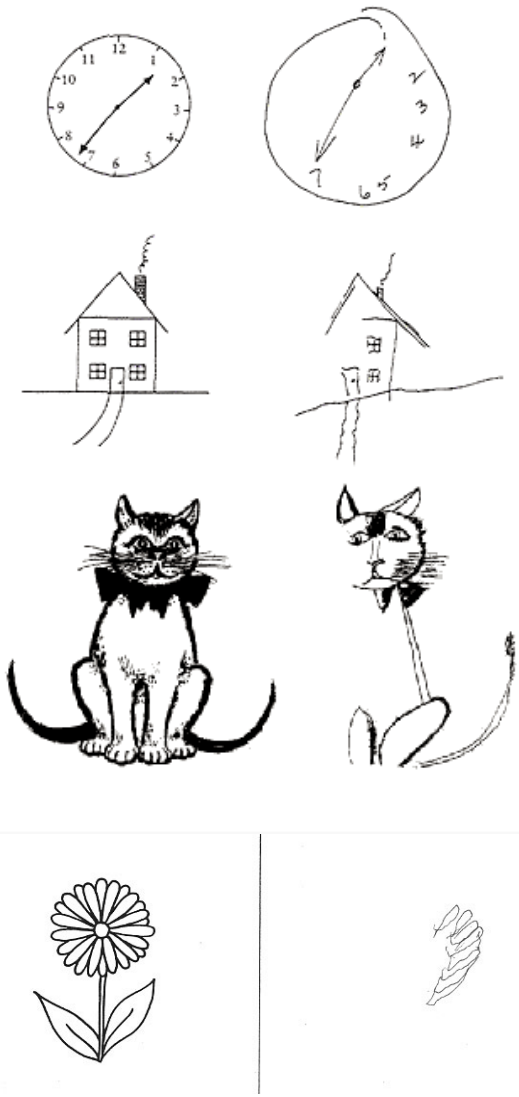
Selective filtering

- **Spatial attention**
  - Focused on one location in space

Attentional deficit: Hemineglect

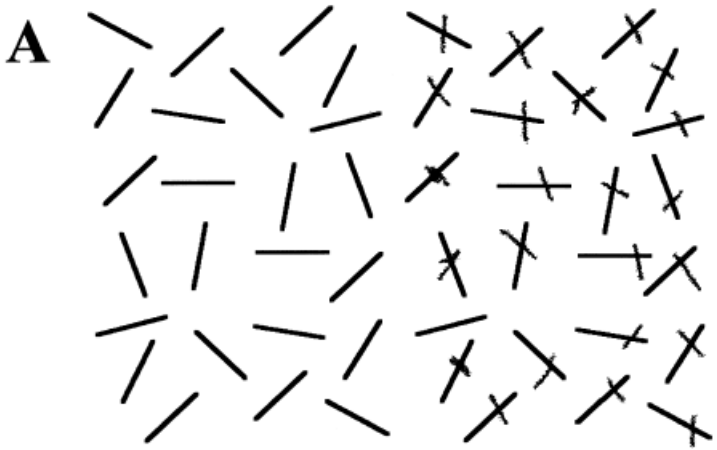
Right parietal lesion



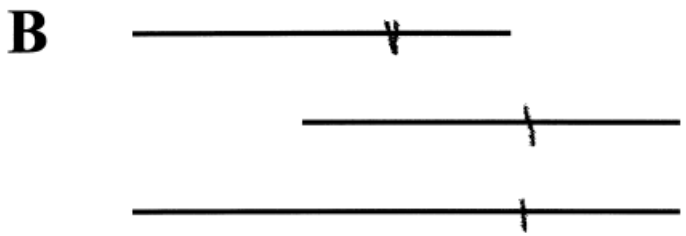


Vuilleumier & Driver (2001)
Vuilleumier & Schwarz (2000)

Attentional deficit: Hemineglect



Crossed out task



Task of segment bisection

Replicating a drawing

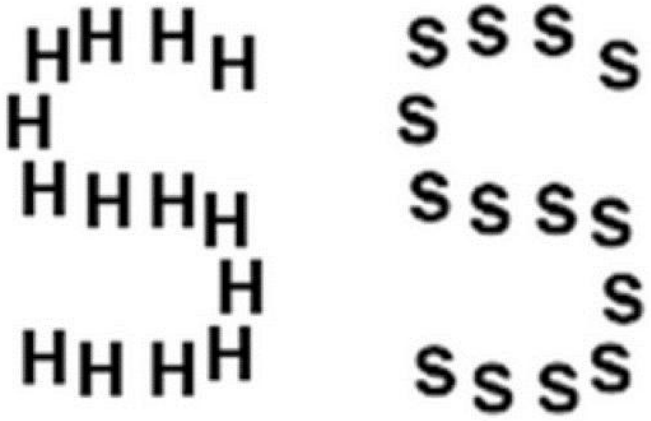
Vuilleumier & Driver (2001)
Vuilleumier & Schwarz (2000)

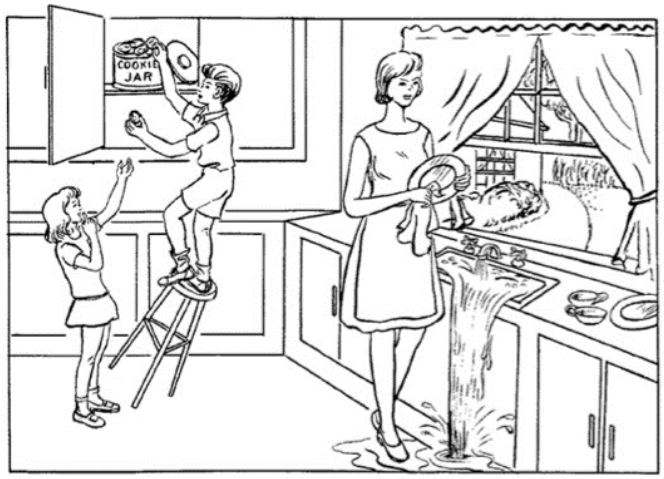
Selective filtering

- **Spatial attention**
  - Focused on one location in space
- **Object based attention**
  - Focused on one particular object

Attentional deficit

- Phenomenon of **extinction / simultagnosia**





Attentional deficit

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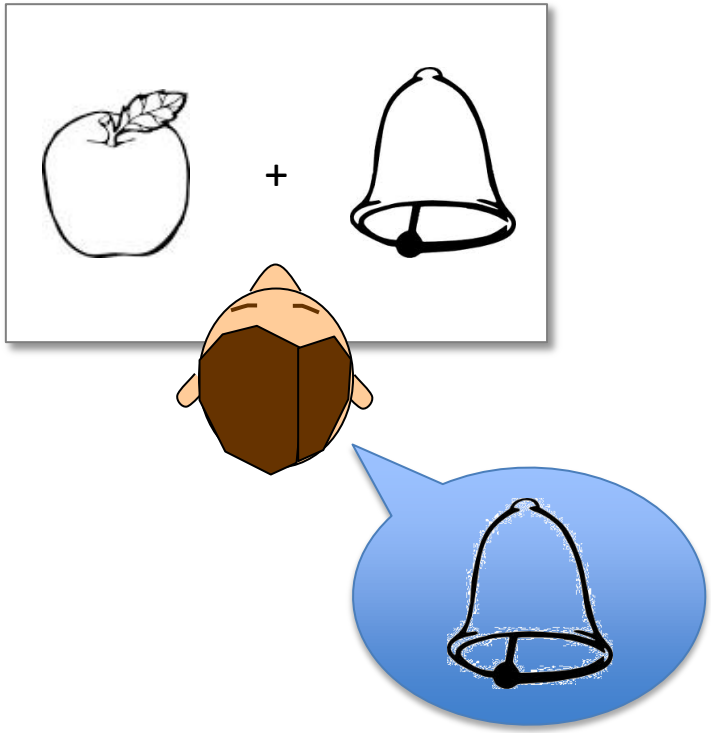
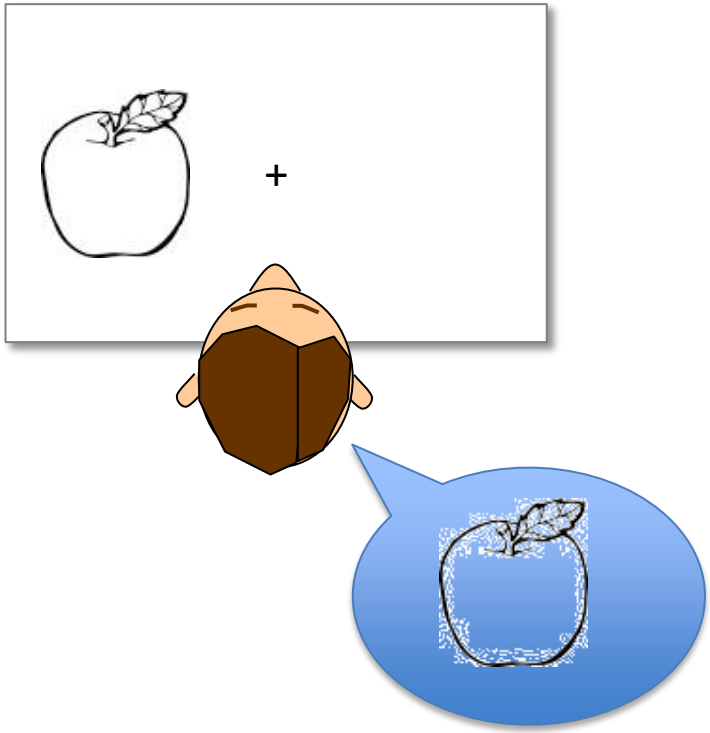
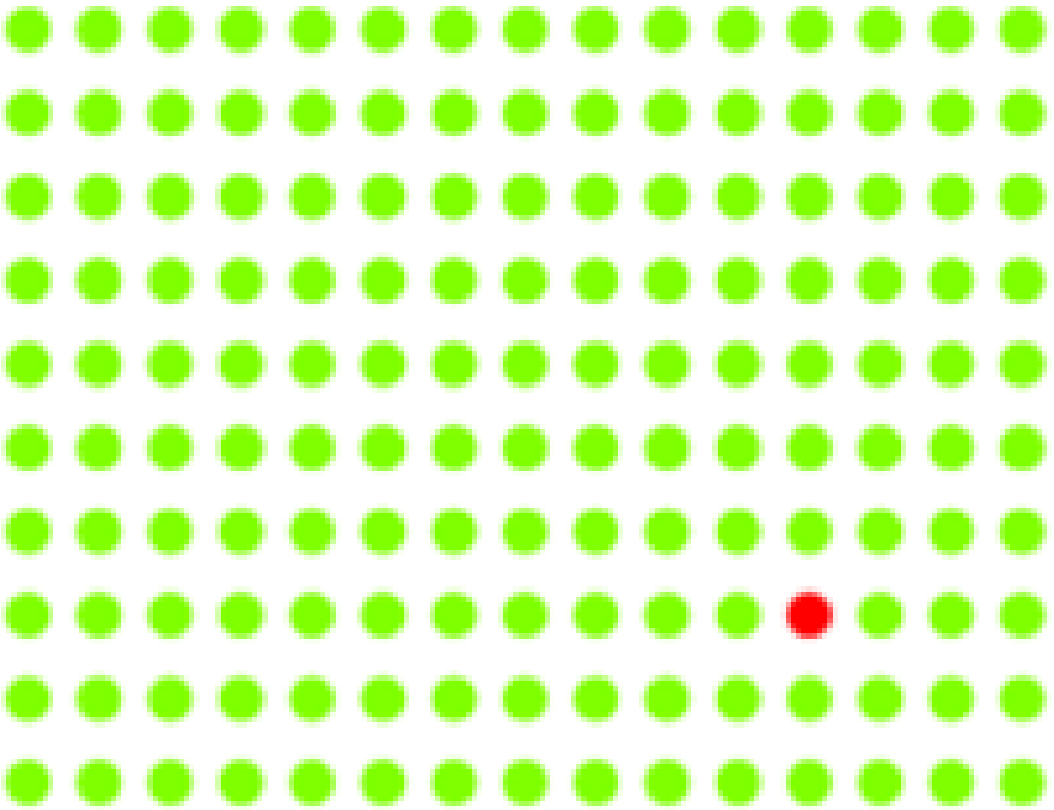




Selective filtering

- **Spatial attention**
  - Focused on one location in space
- **Object based attention**
  - Focused on one particular object
- **Attention based on a primitive**
  - Focused on a particular visual property (e.g., a color, a direction of movement)

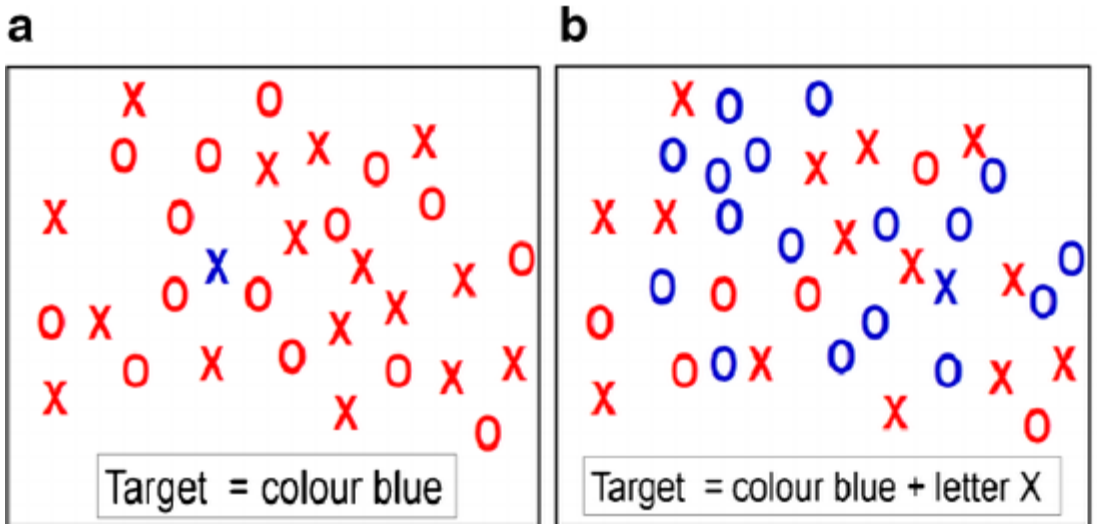
Selective filtering



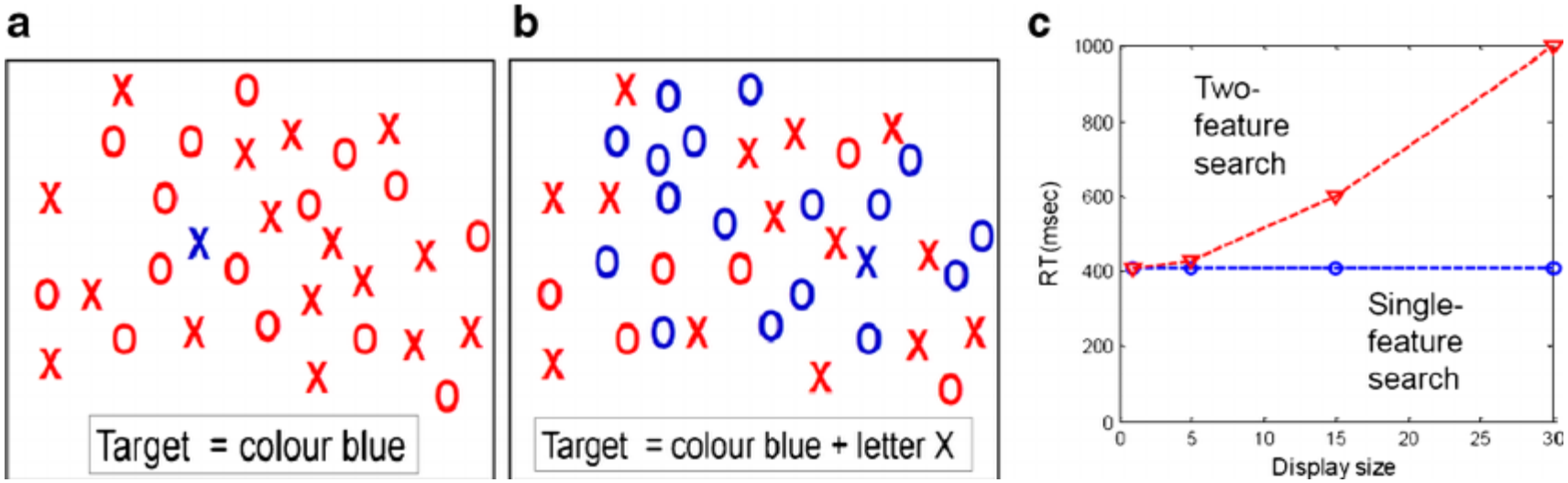
Demonstration

a

Demonstration



Demonstration



Response times increase with the size of the research set.

Shows a serial search and the existence of a system of parallel search for a primitive: a filter.

Definition of attention

- Perceptual binding: theory of traits integration
- Selective filtering: ability to facilitate one type of information (focus) while ignoring another type
- Management of ressources: ability to move, decrease or adapt the size and properties of the attentional focus

Management of attentional ressources

- Principle of limited ressources
  - High energetic cost of neural activity
  - Fast and economical allocation of energy as a function of the requirements for the task to perform

Management of attentional ressources

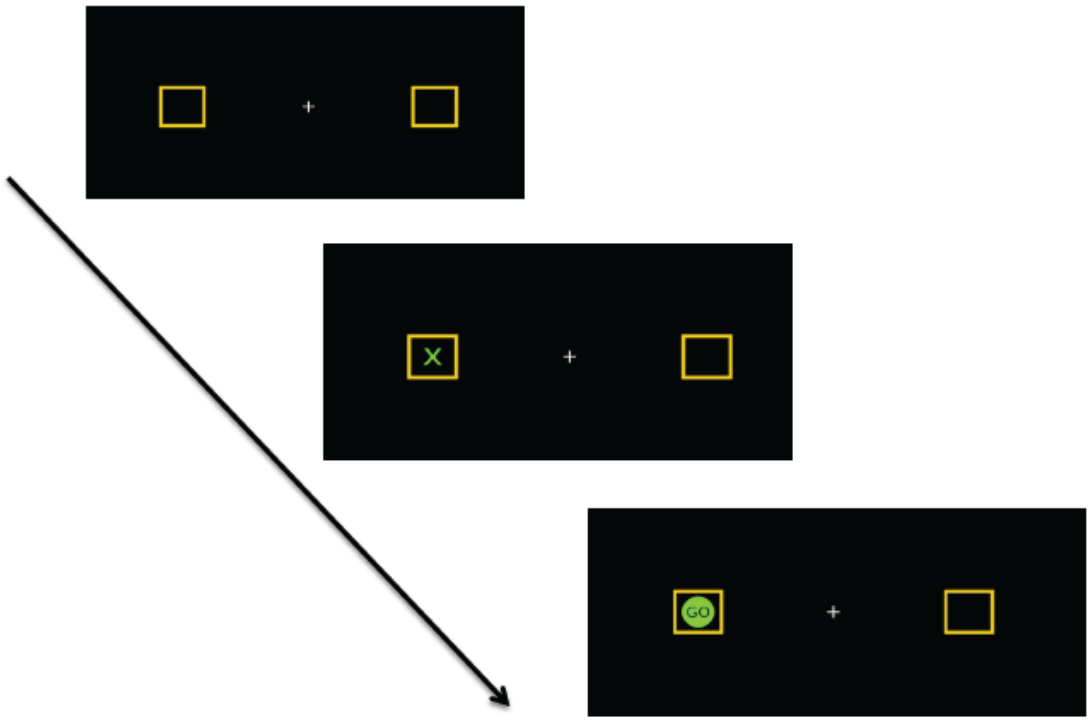
- **Endogenous attention**: voluntary, goal-directed, controlled and sustained

- **Exogenous attention**: involuntary, provoked by a stimulus, automatic and short-lived

  Alert system

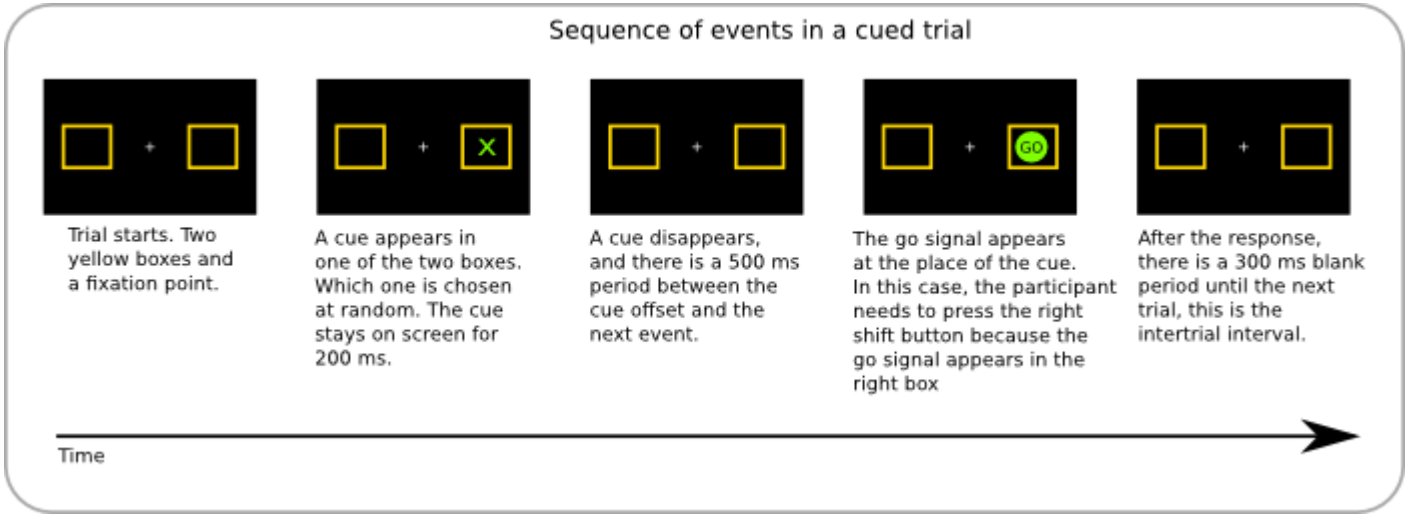
Exogenous attention

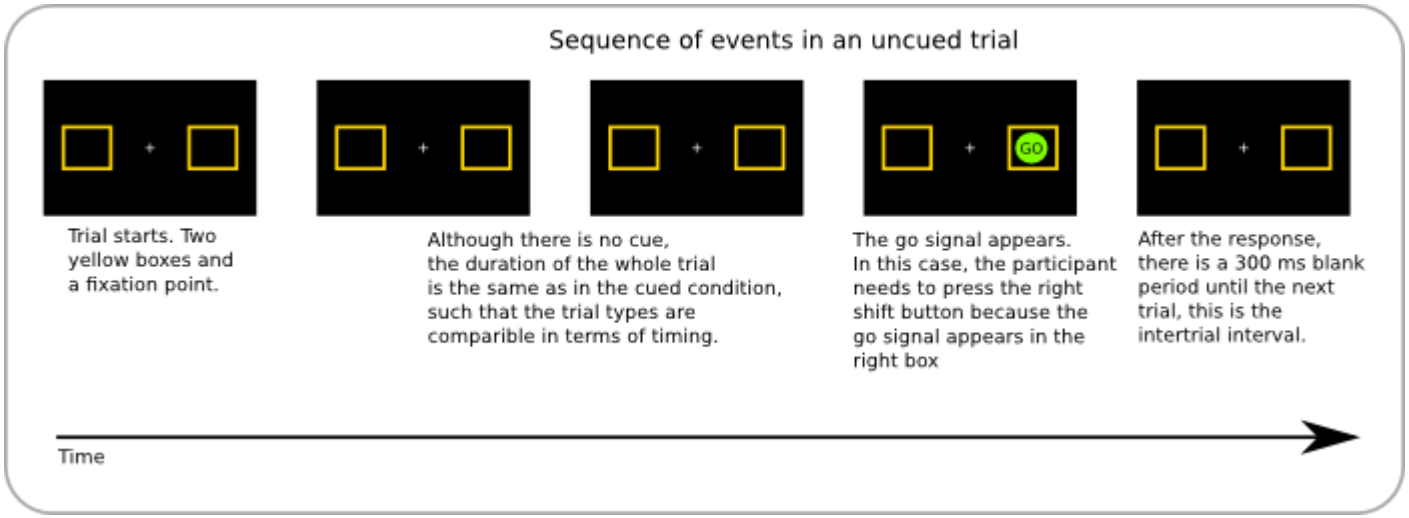
A classical protocol: Posner's protocol



https://www.psytoolkit.org/experiment-library/cueing.html

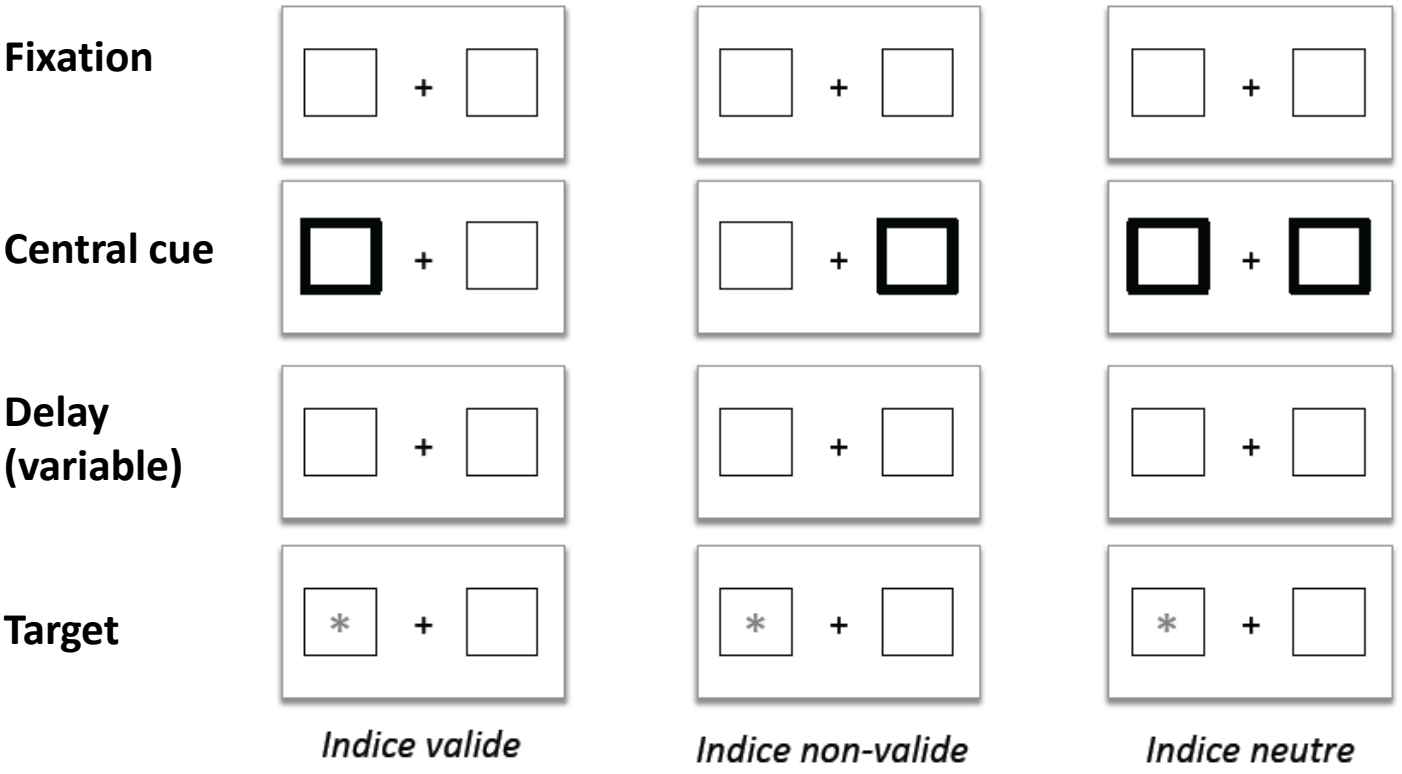
Exogenous attention





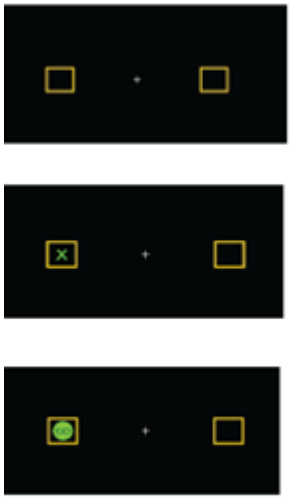
Exogenous attention

A classical protocol: Posner's protocol



Peripheral cue -> Test of exogenous attention

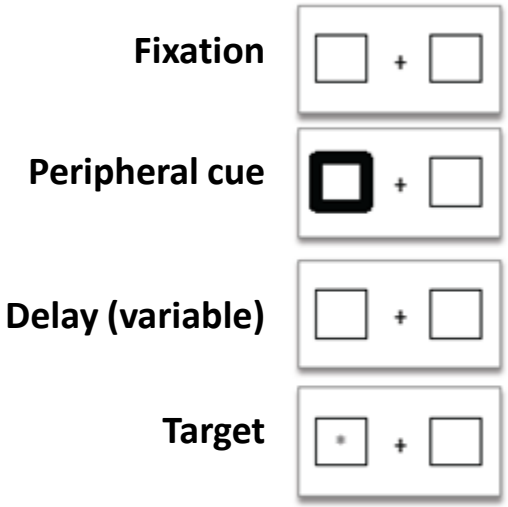
Exogenous attention

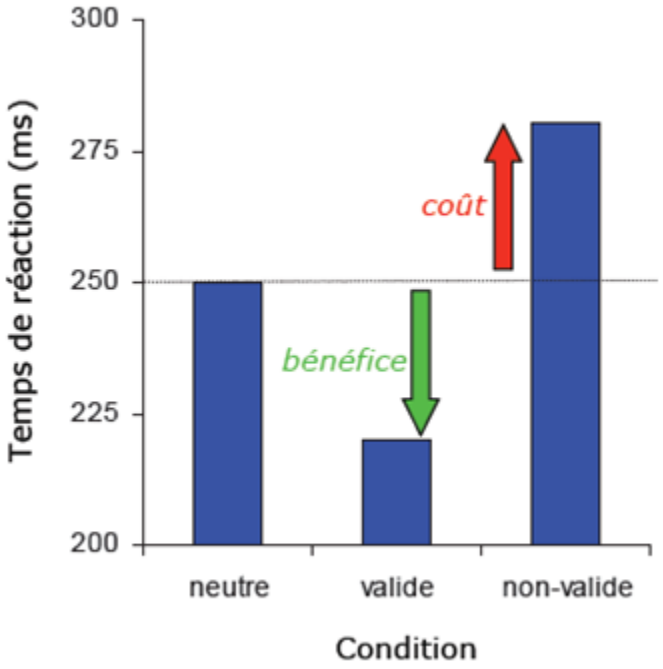


Analysis of the structure of experience

- What is measured? (dependent variable)
- What are the main factor of this experience? (i.e., the parameters that vary in a systematic way and that correspond to the hypotheses
- What are the parameters that are fixed but important for the experiment?
- Are there other factors that can influence the results and that are not counterbalanced here?
- Which kind of attention is tested here?
- What are your predictions on the results?

Exogenous attention

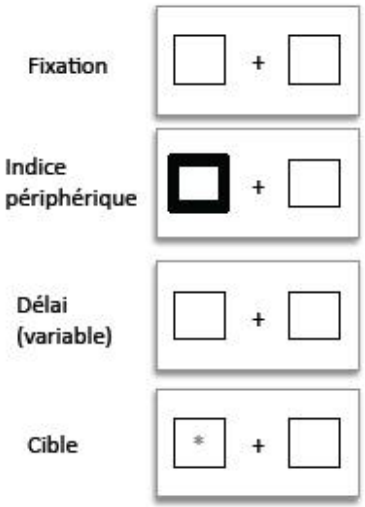




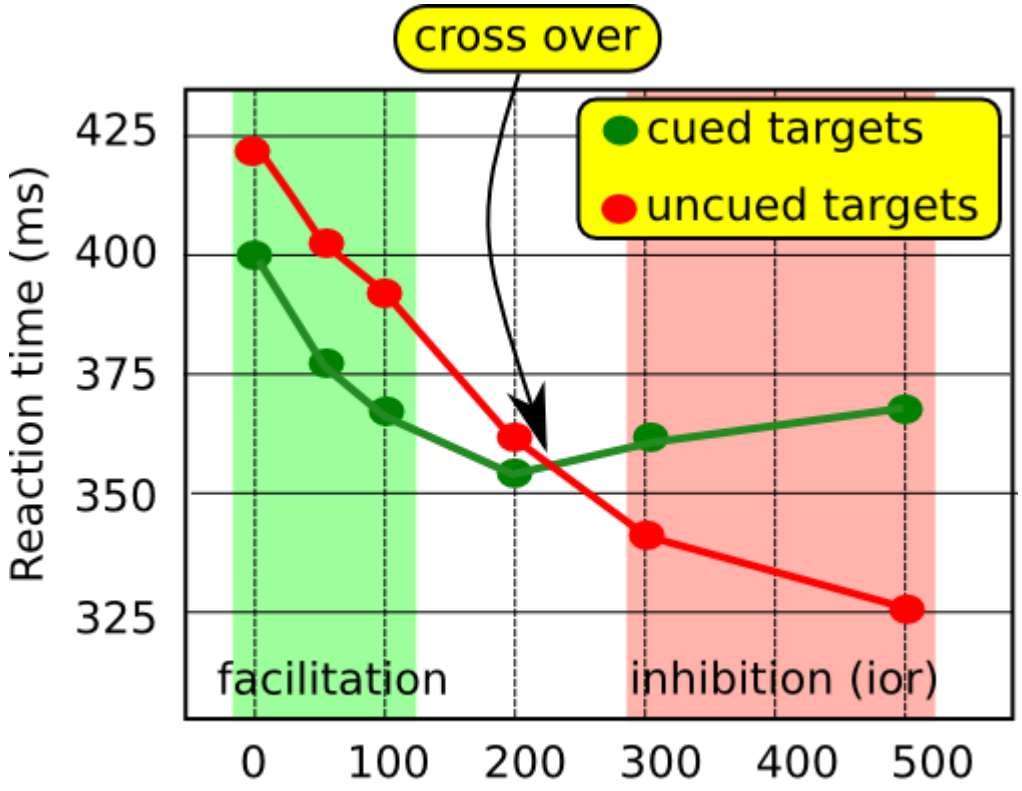
How can we know the temporal decay of this effect?

Exogenous attention

Temporal decay of exogenous attention



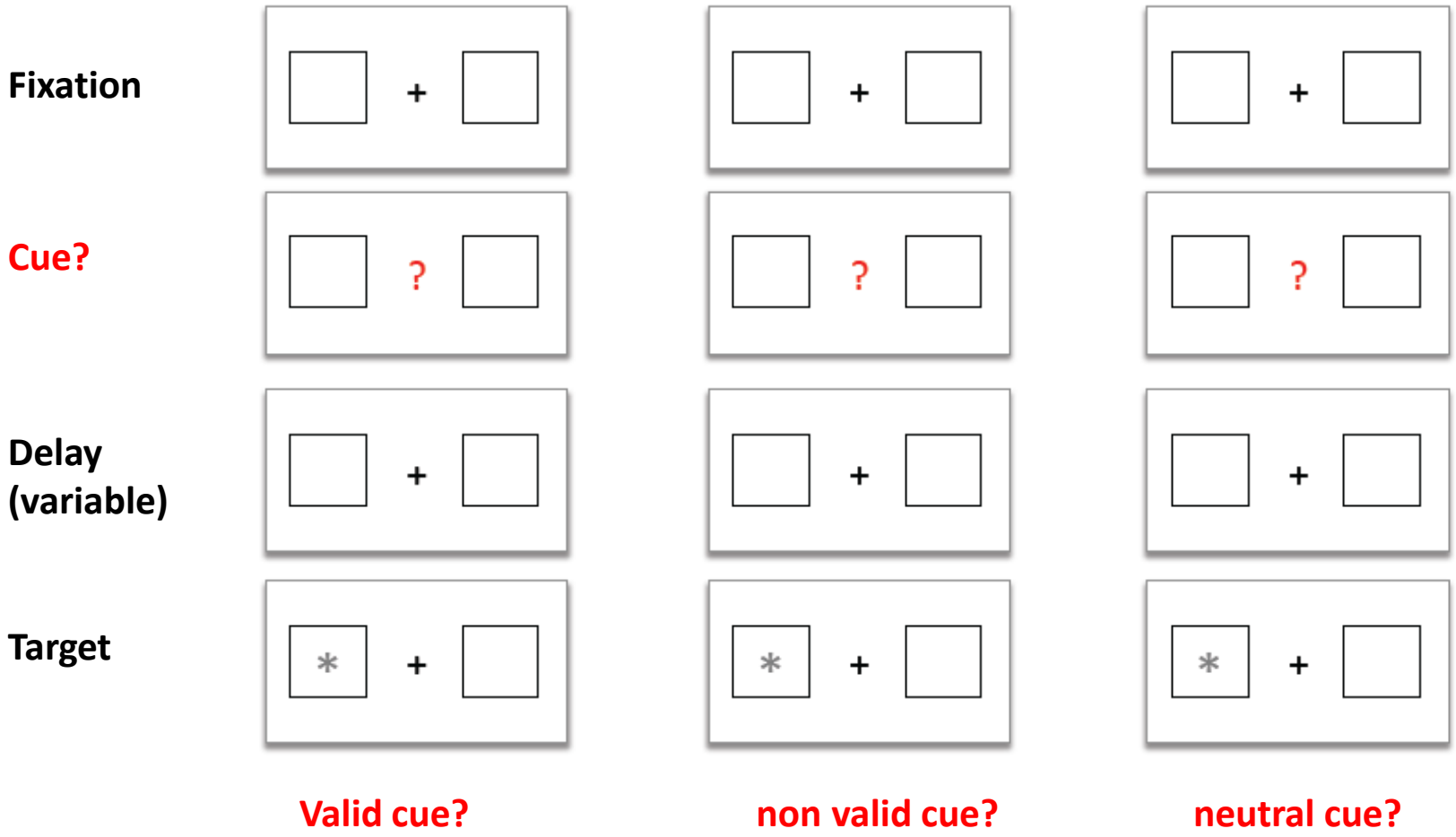
Effect of the delay between the peripheral cue and the target



Attention increases both reaction time and performance

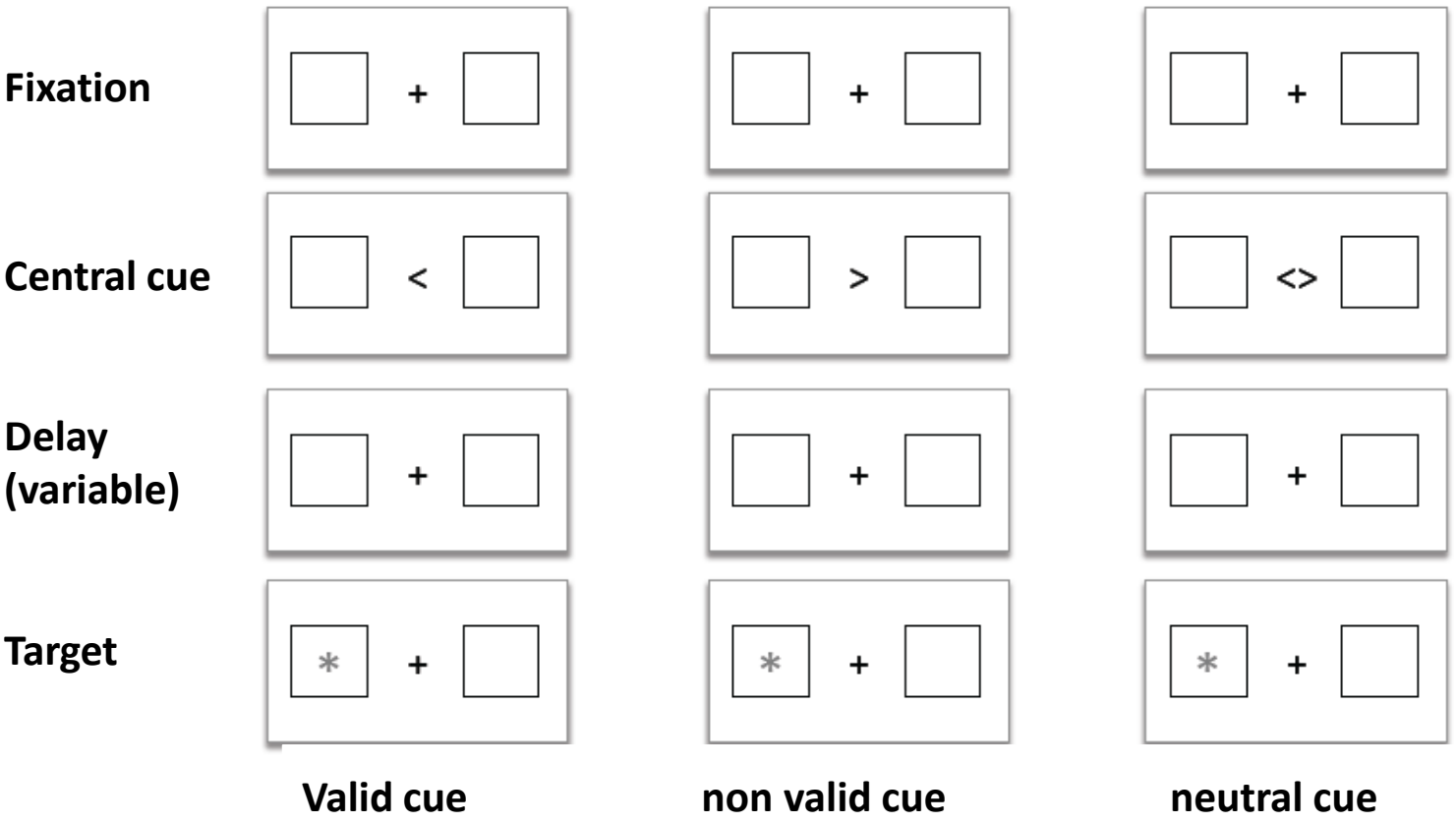
Endogenous attention

Testing endogenous attention with a similar protocol?



Endogenous attention

Variants of Posners' protocol



Central cue -> test endogenous attention

Management of attentional ressources

Timing of spatial attention

Initial survey

How long does it take to re-orient attention toward a novel object, about …

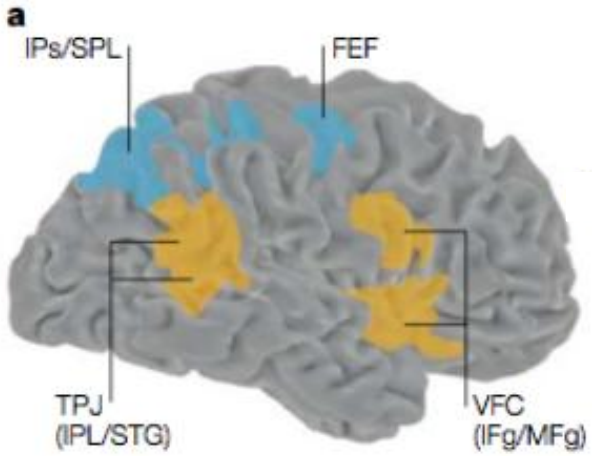
1 ms	A
10 ms	B
100 ms	C
500 ms	D
1 sec	E
10 sec	F

Experimental results

Manifest vs. discrete attention

- **Manifest attention (overt)**
  - Foveal attentional focus, which follows the movement eye/head
- **Discrete attention (covert)**
  - Displacement of the attentional focus outside of the fovea, in the absence of eye/head movements
  - Can be used to guide these movements

High level areas involved in attention



Cortical areas involved in attention:

Parietal lobe

. Intraparietal sulcus

. Superior parietal lobe

. Temporo-parietal junction

Frontal lobe

. Frontal eye Field

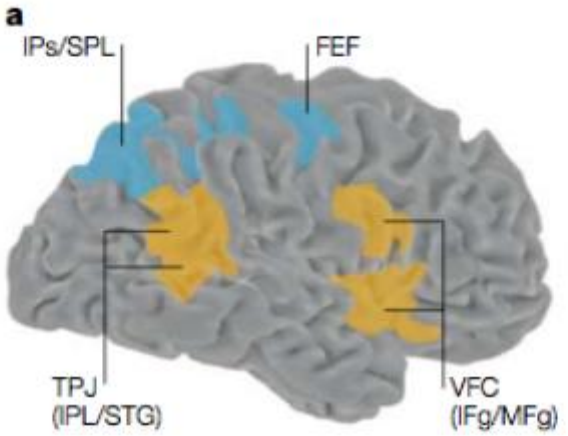
. Inferior frontal gyrus

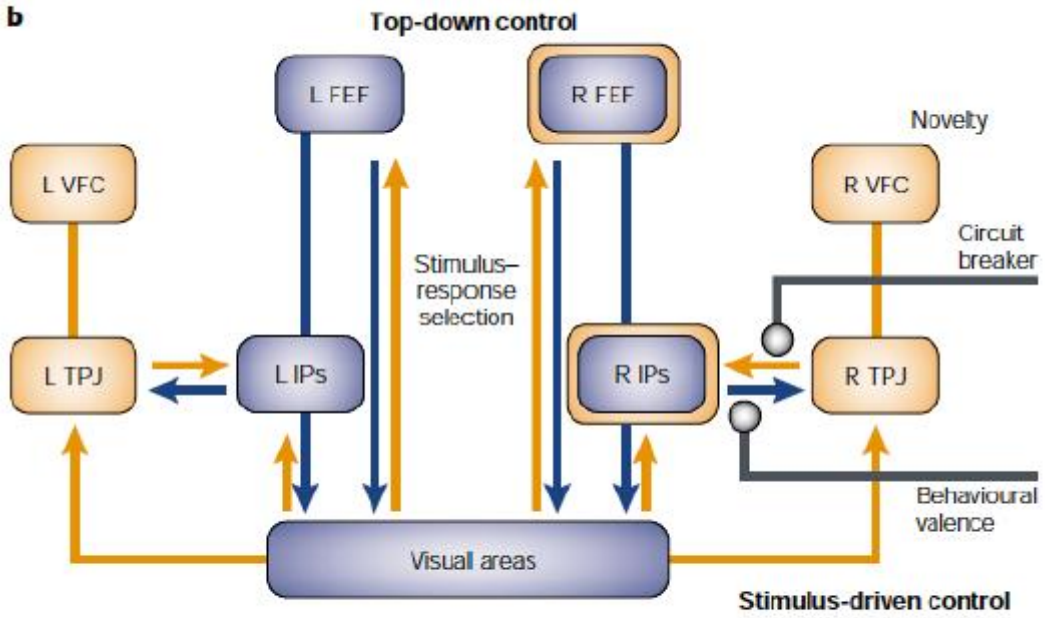
. Median frontal gyrus

Corbetta, Patel & Shulman, Neuron 2008

High level areas involved in attention

Two systems interact:
-Sustained attention (IPS/ SPL and FEF)
- Reorientation of attention (TPJ/VFC)





Corbetta, Patel & Shulman, Neuron 2008

Summary

- Attention has several dimensions (filtering, binding) and several properties (endogenous, exogenous)
- Attention is underlied by specific brain areas
- Attention increases the efficiency to process information by pre-activating the appropriate sensory area

The visual system in action: visual search

The visual system in action: visual search

Some search seems easier than others

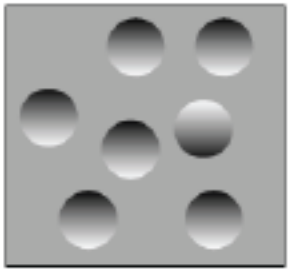
The visual system in action: visual search

Some caracteristics can automatically attract attention (exogenous attention), it's the « pop up » phenomenon

Orientation

color

size



3D

But it depends on the context

The visual system in action: visual search

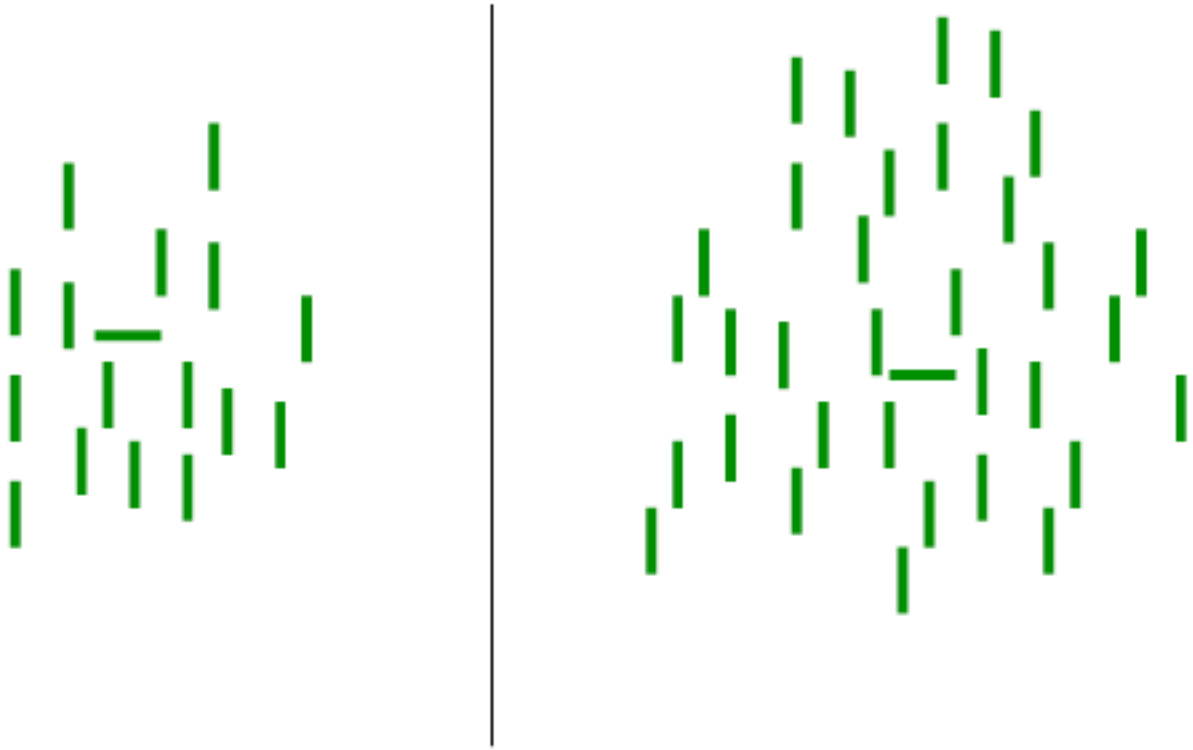
Finding the right camouflage: it's misleading the predator's attentional system

The fish can be taken for the surrounding gravel

The visual system in action: visual search

Finding 

In which side is it easier?



The visual system in action: visual search

Finding 

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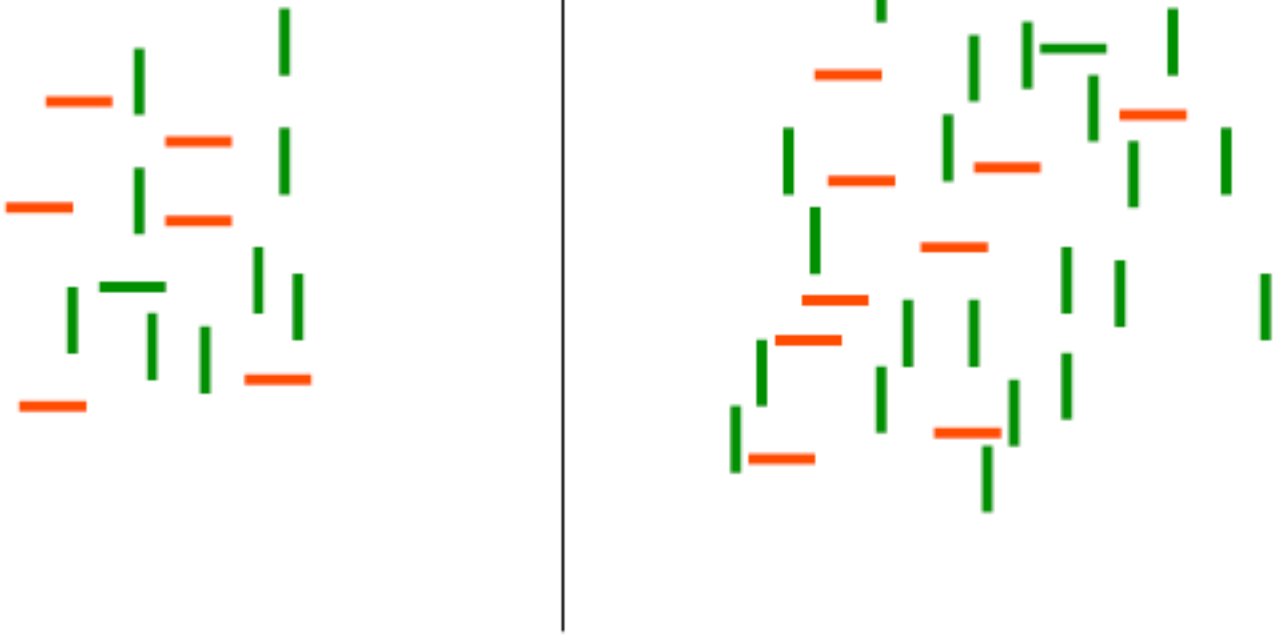
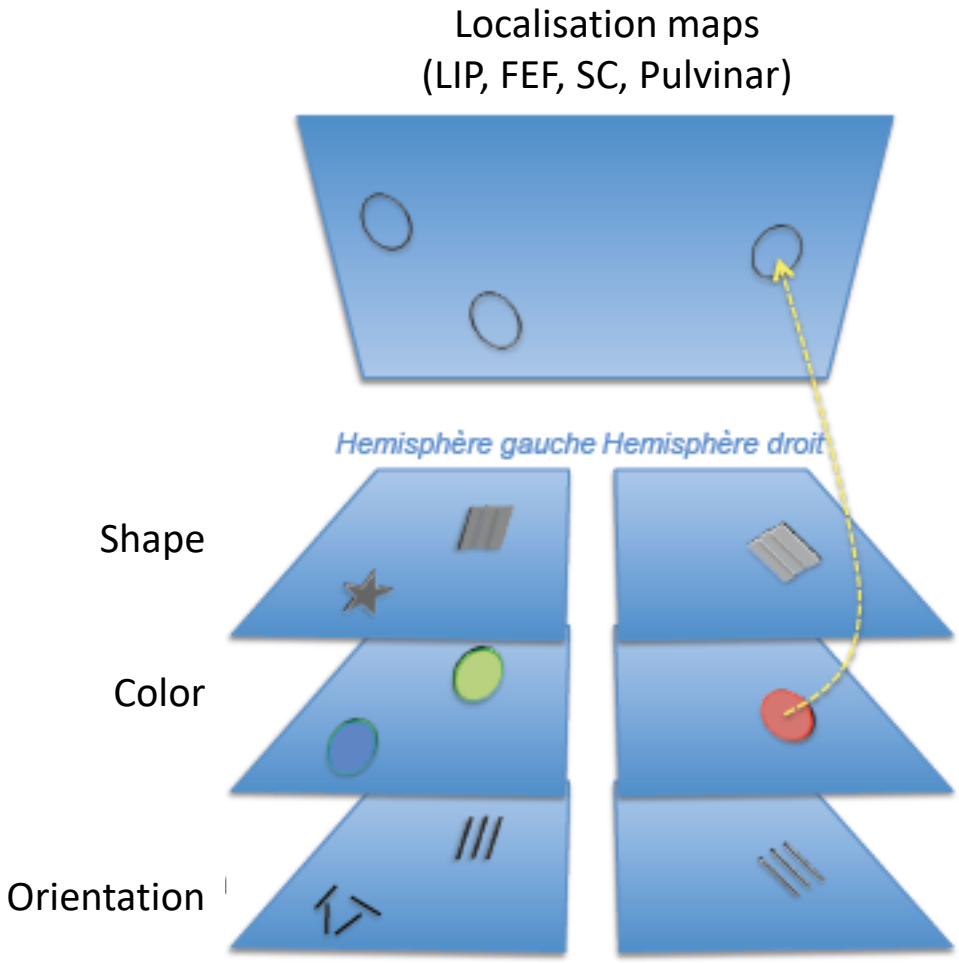


The visual system in action: visual search

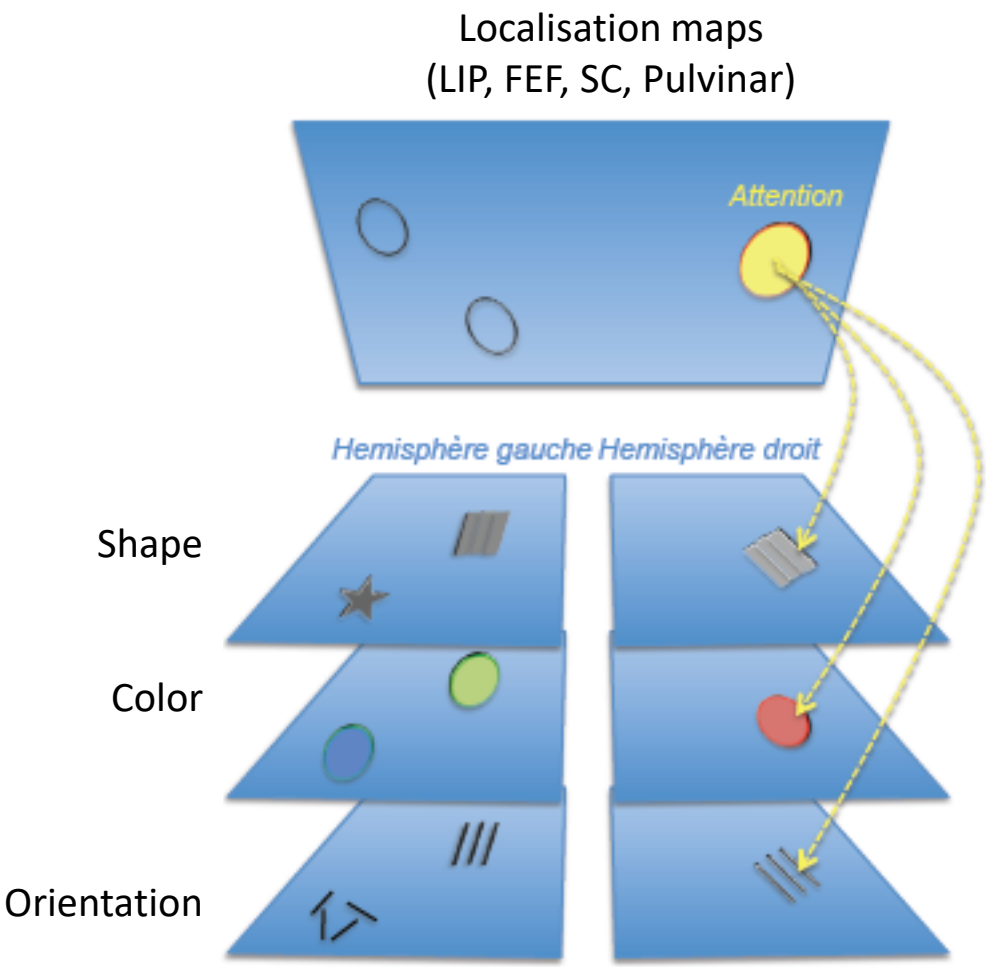
I'm looking for something red

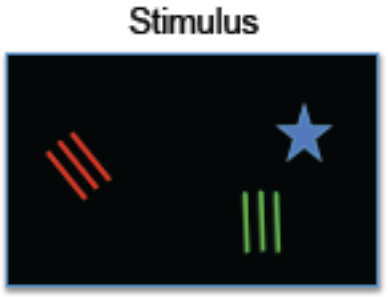


If the target is defined only by this attribute, I'll find it directly

The visual system in action: visual search

I'm looking for something red

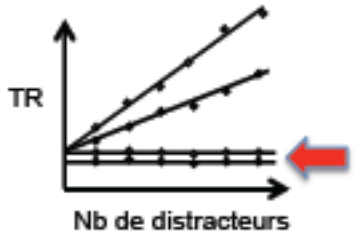




If the target is defined only by this attribute, I'll find it directly

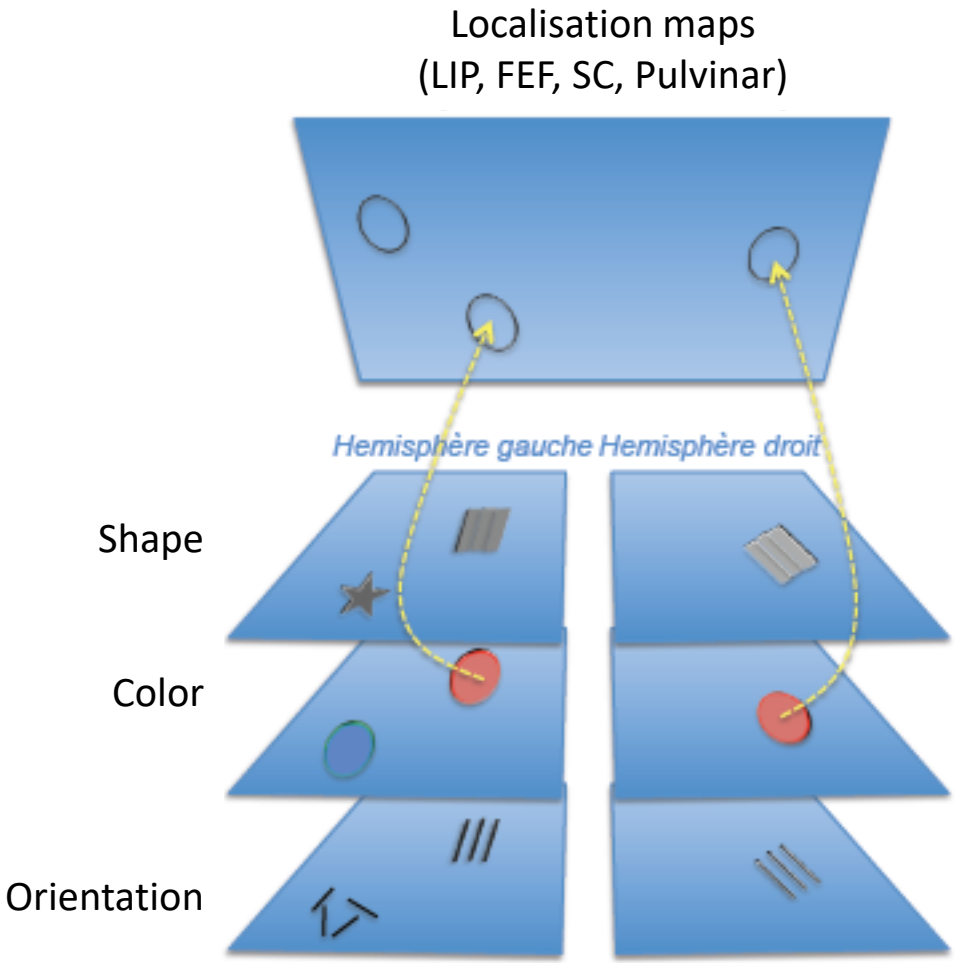
- It orients on it the focus of spatial attention

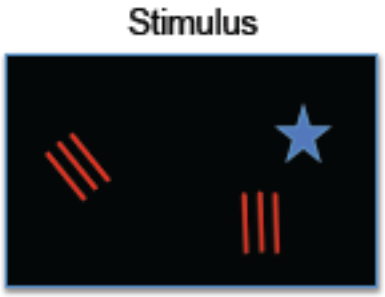
- My reaction times does not depend on the number of distractors



The visual system in action: visual search

I'm looking for something red and vertical



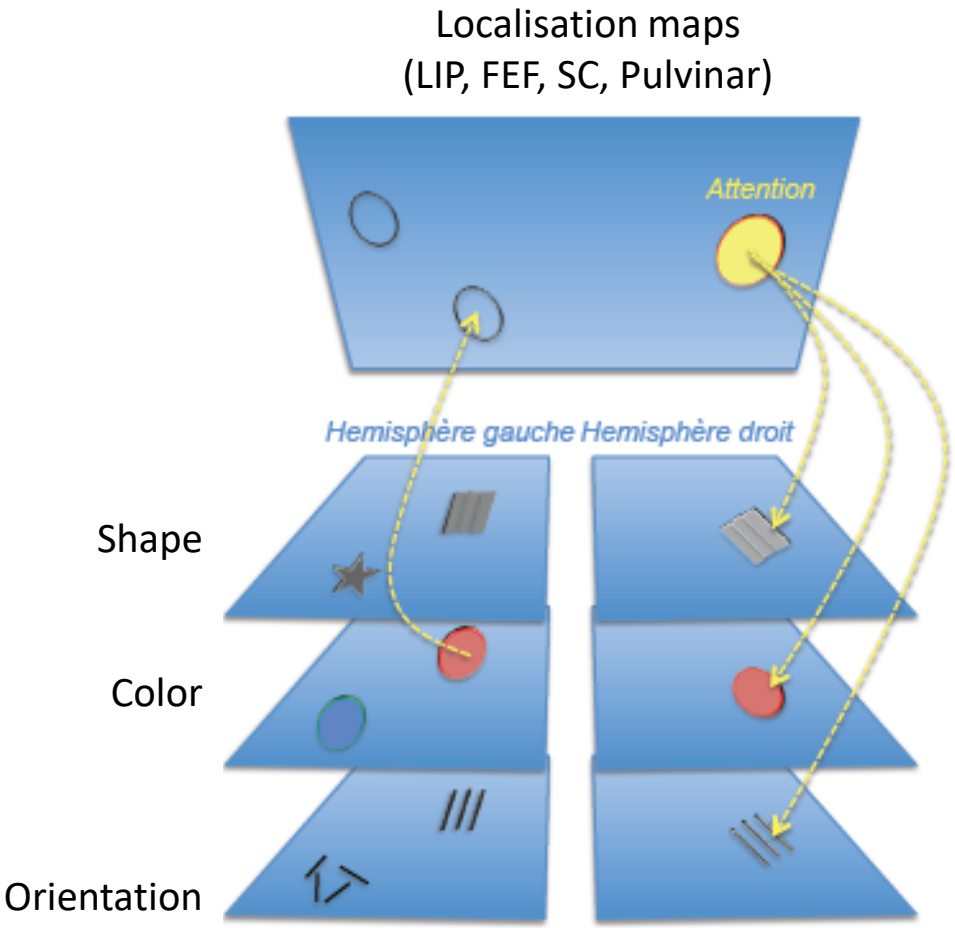


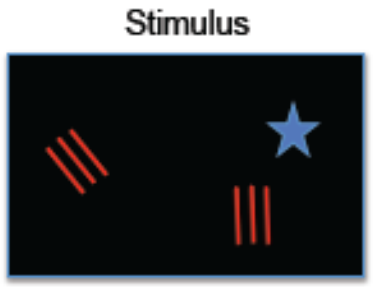
If several targets are red, several positions become salient at the same time.

- Each of them will be examined by focal attention until I find the correct one.

The visual system in action: visual search

I'm looking for something red and vertical





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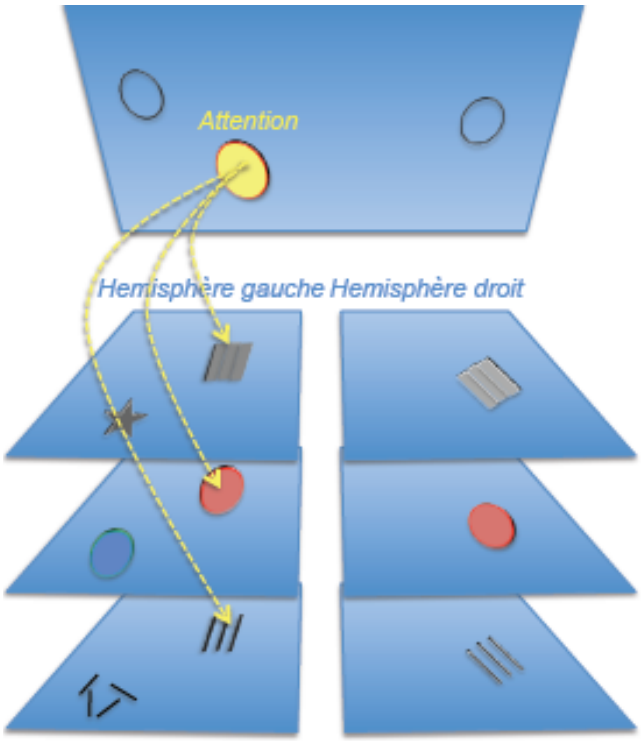
The visual system in action: visual search

I'm looking for something red and vertical

Localisation maps
(LIP, FEF, SC, Pulvinar)



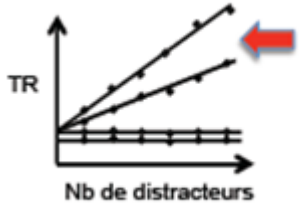
Maps of attributes
(V1-V4, MT, LOC)

Stimulus

If several targets are red, several positions become salient at the same time.

- Each of them will be examined by focal attention until I find the correct one.

My reaction times increases with the number of distractors



The visual system in action: visual search

With scenes in real life?

We also find this linear relationship

However, the slope is smaller: the search becomes more efficient due to our a priori-knowledge: we know where to search.

First 3 fixations to find a person in these environments

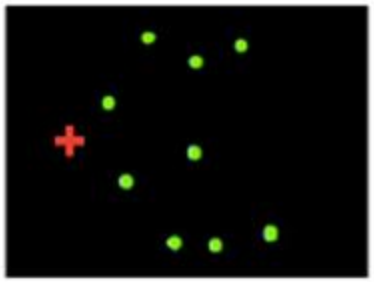
Peelen & Kastner, TICS 2014

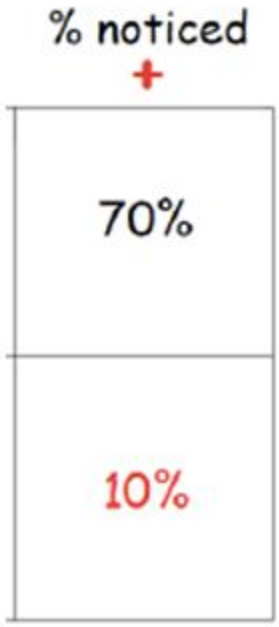
The visual system in action: visual search

Attentional load in real life

Detecting one salient element (the red cross)

- While following several targets
- While following several targets and speaking on the phone





Sholl et al 2003

Rich and detailed perception of the visual world

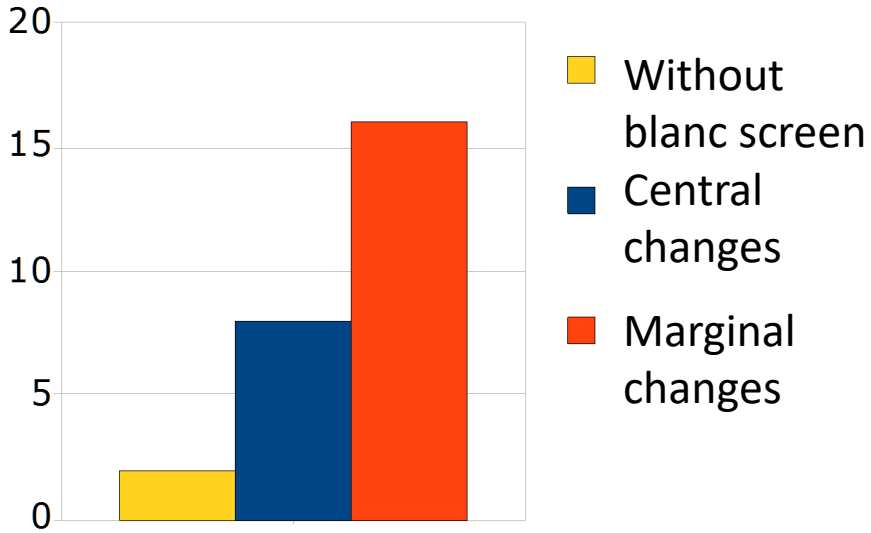
- When looking at a visual scene, we have the impression to see the whole of it in great details

- Is it really the case?

Attentional blindness

Change blindness

- Images lasting 240ms separated by a 80 ms blank screen



Rensink, O'Regan & Clarck, 1997

Change blindness

Conclusions

1) We perceive a visual scene as through a tube: the elements are selected by the **attentional focus**.

2) In order to be perceived, the elements must be converted into an **abstract non-visual format**.

3) We do not have a complete visual representation of the world.

Rensink, O'Regan & Clarck, 1997

Controversies

(1) Forgetting / degradation

There are complete and detailed representations, but they deteriorate before the perception of a change occurs.

<u>Forgetting during the white screen</u>

No because camera-cut = immediate change

Simons, 2000 ; Simons et Rensink, 2005

Controversies

(2) Replacement / crush
There are complete and detailed representations, but they are replaced before the perception of a change occurs.

No, because the experience of slow changes

O'Regan, Rensink, & Clark, 1999
Simons, Franconeri & Reimer, 2000

Slow changes

Controversies

(3) First impression

The first image is stored detailed, but the observer is enable to update it.

No, because experience of mudsplashes.

Conclusions

1) We perceive only through the tube of the attentional focus, in an abstract non-visual format.

2) We use the world as an external memory.

3) The warning system allows us to know where to update the changes in the world.

Real-world interactions

Necessity of attention even at the point of interest

Adaptation: Derren Brown

Simons & Levin, 1998