Attention

Zoran Đogaš

Lecture Outline:

- What is attention?
- Different types of attention
- Neurophysiology of attention
- Neglect
  - Clinical features
  - Motor, sensory and motivational aspects of neglect
  - Where does the neglect occur?

Looking without Seeing


THE GEORGE


BREITLING
VINEYARD HOTEL
dirtopia
341


AirEuropa


thansa
D-ABVA

Visual Attention

Visual Attention

What is Attention?

- “Everyone knows what attention is.”
  - William James, 1890
- “No one knows what attention is.”
  - Harold Pashler, 1998
- Attention is a well-studied phenomenon, but hard to define

What is Attention?

- It is more than just sensation and perception
- Attention and arousal are not synonymous
- There can be attentional deficits in perfectly awake individuals
- Extreme arousal (as in pain or terror) may impair the flexibility of attention

- https://www.youtube.com/watch?v=vJG698U2Mvo
- http://www.theinvisiblegorilla.com/videos.html

What is Attention?

- **Two primary themes characterize attention:**
  - **Perceptual gating (selection)**

    Conscious perception is always selective,

    but selection is not always conscious

  - **Capacity limitation**

    Our limited ability to carry out various mental operations at the same time

What is Attention?

- **Attention:** ability to detect and respond to stimuli
- Attention is not a unitary construct
- just like memory there are many different types of attention
- **At the psychological level:** attention implies a preferential allocation of processing resources and response channels to events that have become behaviorally relevant
- **At the neural level:** attention refers to alternations in the selectivity, intensity and duration of neuronal responses to such events

Types of Attention

1. **Alertness and arousal** – the basic aspects of attention that enable a person to extract information from the environment or to select a particular response (coma → full alertness)
2. **Vigilance** (sustained attention) – the ability to sustain alertness (monitor an even or stimulus) continuously (adhd)
3. **Selective attention** – ability to scan events/stimuli and pick out the ones that are relevant (difficult to monitor two events in the same modality)

Limited resources

- The high-energy cost of neuronal activity involved in cortical computation limits our ability to process information:
  - constant overall energy consumption available to the brain
  - neuronal metabolic cost depends on the spike rate
  - the cost of a single spike is high
  - average discharge rate of active neurons will determine how many neurons can be active concurrently […1%!]

- The brain needs machinery for the system to allocate energy according to task demand… selective attention.

Lennie, Current Biology 2003

Selective Attention

- … the amount of information coming down the optic nerve - estimated to be in the range of 10^8 ~ 10^9 bits per second - far exceeds what the brain is capable of fully processing and assimilating into experience …

  C. Koch (2004)

- Selective Attention (processing input preferentially) is the natural strategy for dealing with this bottleneck.

Selective Visual Attention

- **Capacity Limitation**
  - **As visual information traverses the successive cortical areas of the ventral visual stream, the size of receptive fields increase.**
  - **Neurons in higher order areas with large receptive fields have to deal with many visual stimuli that appear simultaneously within their receptive fields.**
  - **This is why the neurons which make up the visual system are limited-capacity channels.**

Bottom-up and Top-down Processes

- **Bottom-up processing** – processing that starts with unprocessed sensory information and builds toward more conceptual representation

- **Top-down processing** – processing in which conceptual knowledge influences the processing or interpretation of lower level perceptual processing

Visual Pop-Out:
RT does not increase with Display Size
Find the blue “S”

- Easy:

X T X T
X T S X
T X X X
T T X T

- Just as Easy:

X T X T T T X T
X T X X T X T T
T X S T X X T X
X X T X T X T X
T X T T X T X T

No Visual Pop-Out:
RT increases with Display Size

Find the green “T”

- Hard:

X T X T

X T T X

T X X X

T T X T

- Even Harder:

X T X T T T X T

X T X X T X T T

T X X T X T T X

X X T X T X T X

T X T T X T X T

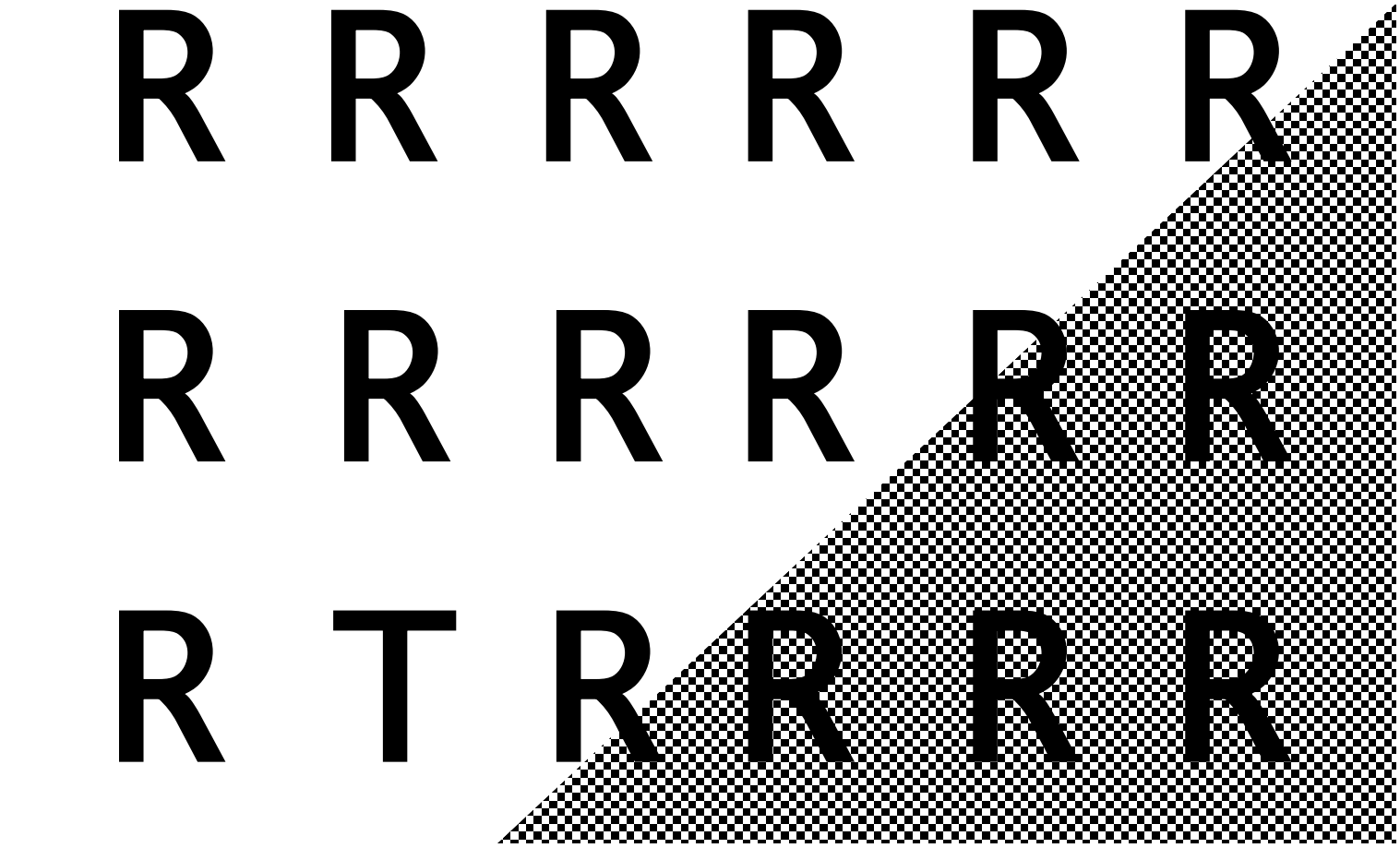
Find the T

R R R

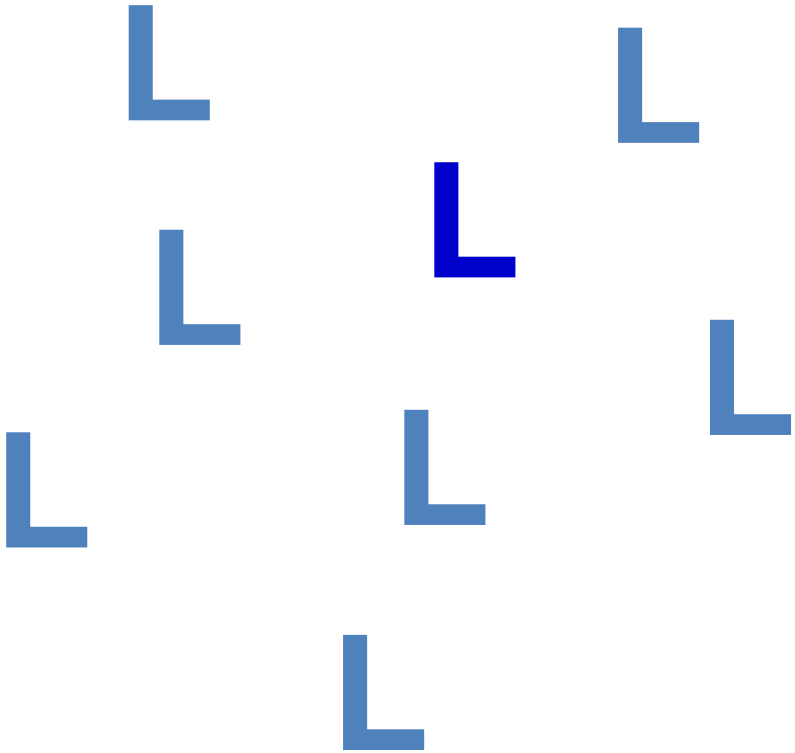
R R R

R T R

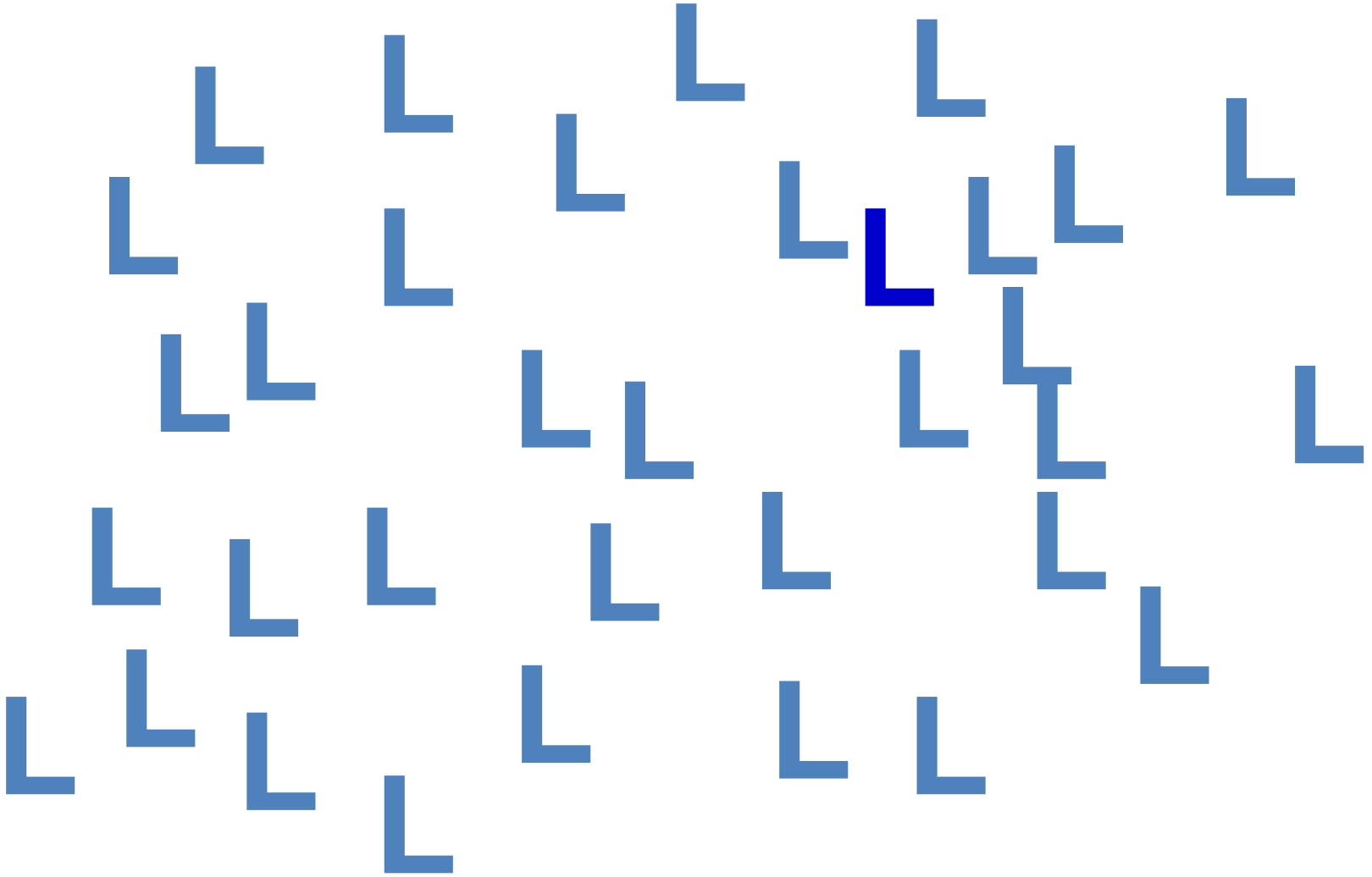
Find the T



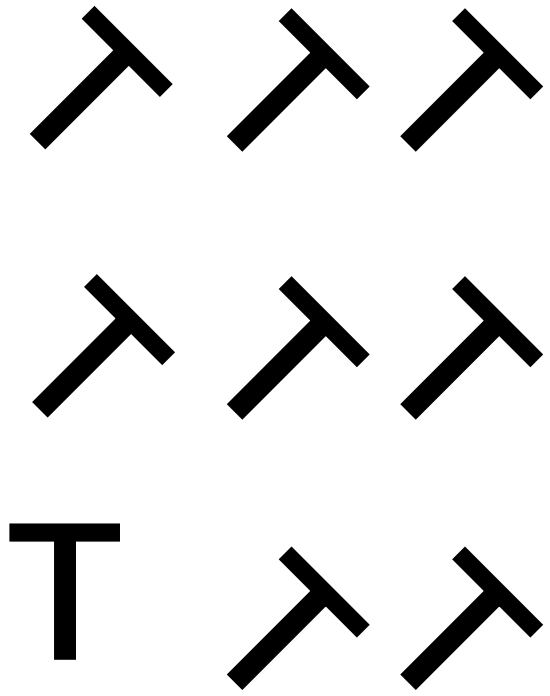
Find the Blue Letter



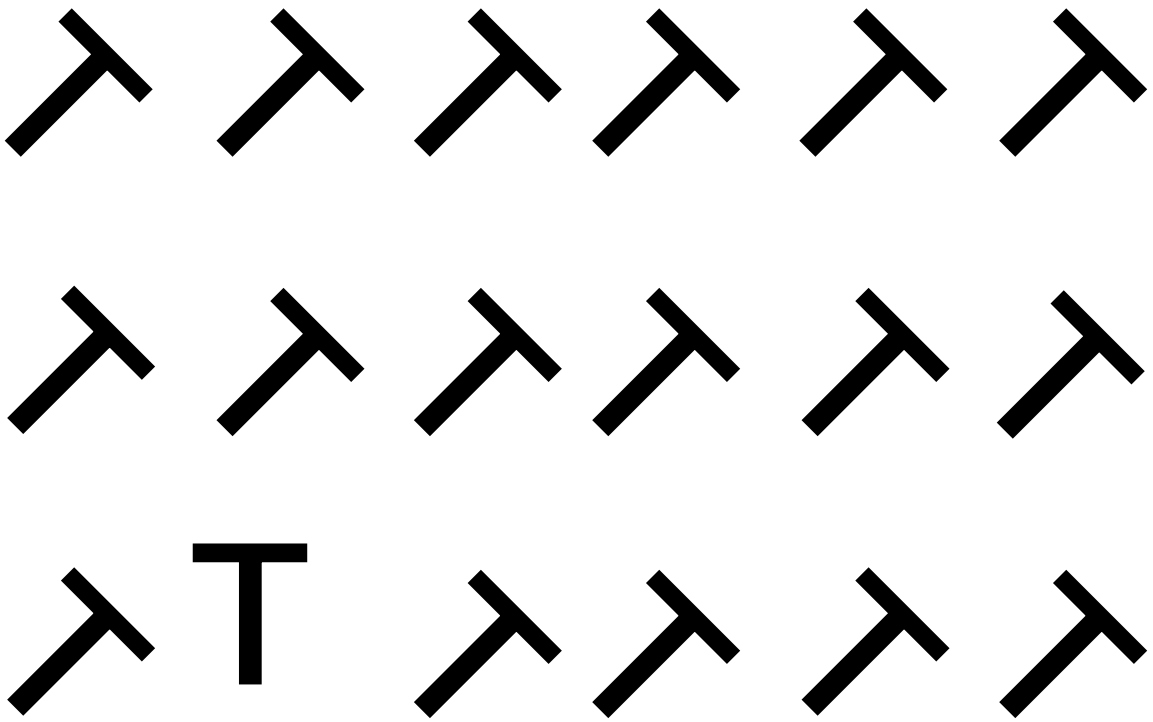
Find the Blue Letter



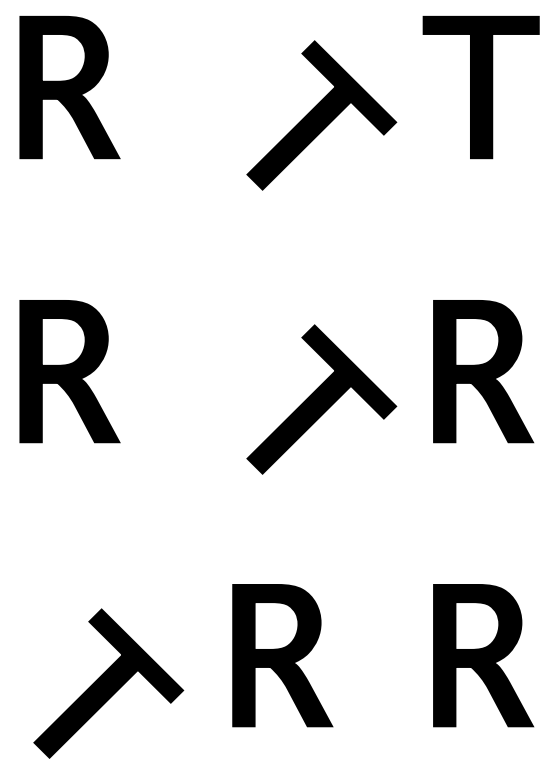
Find the vertical T



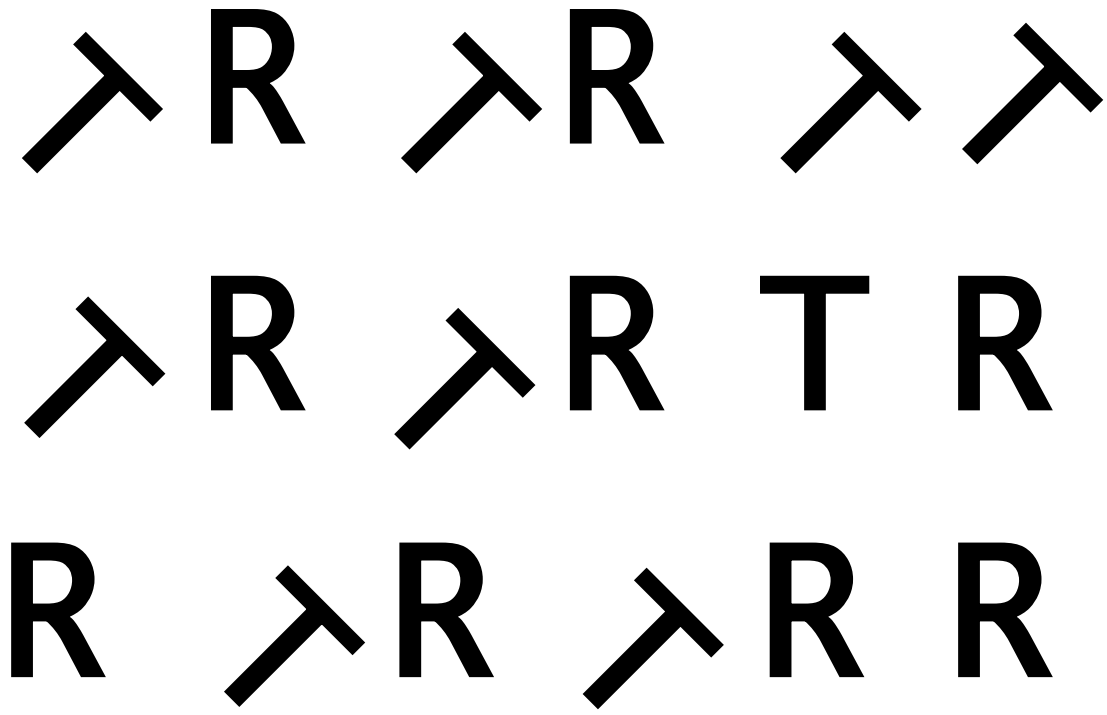
Find the vertical T



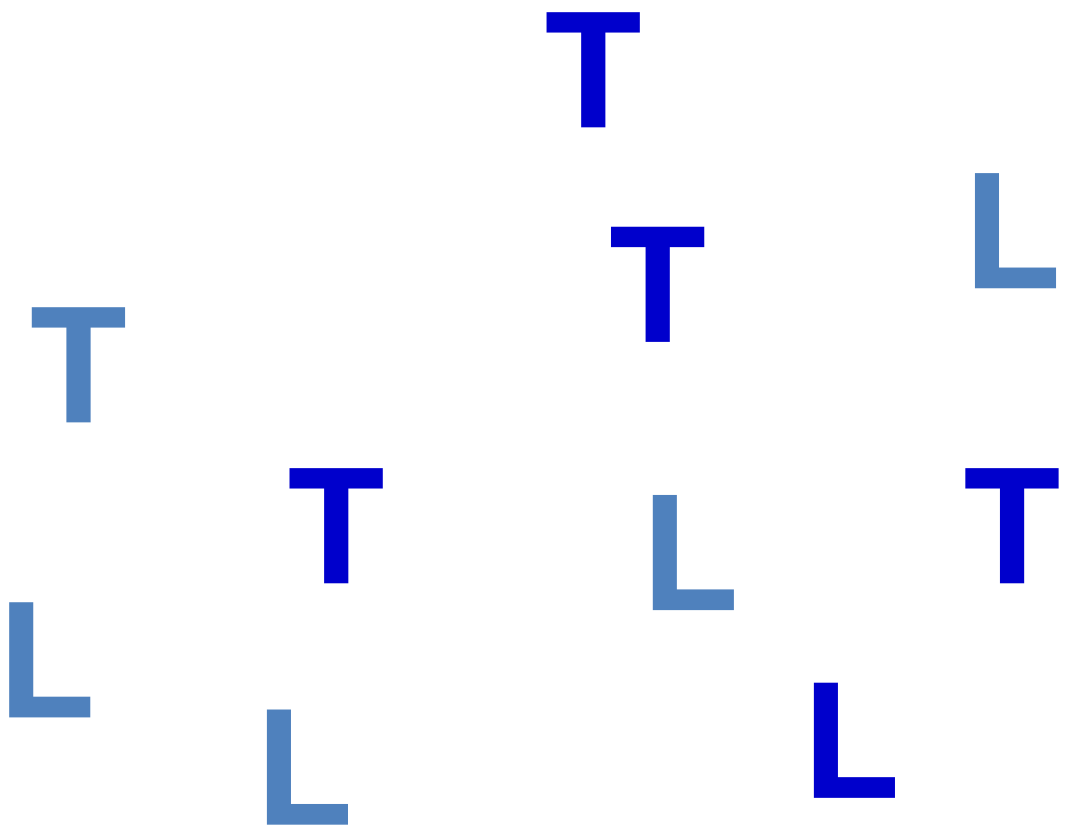
Find the vertical T



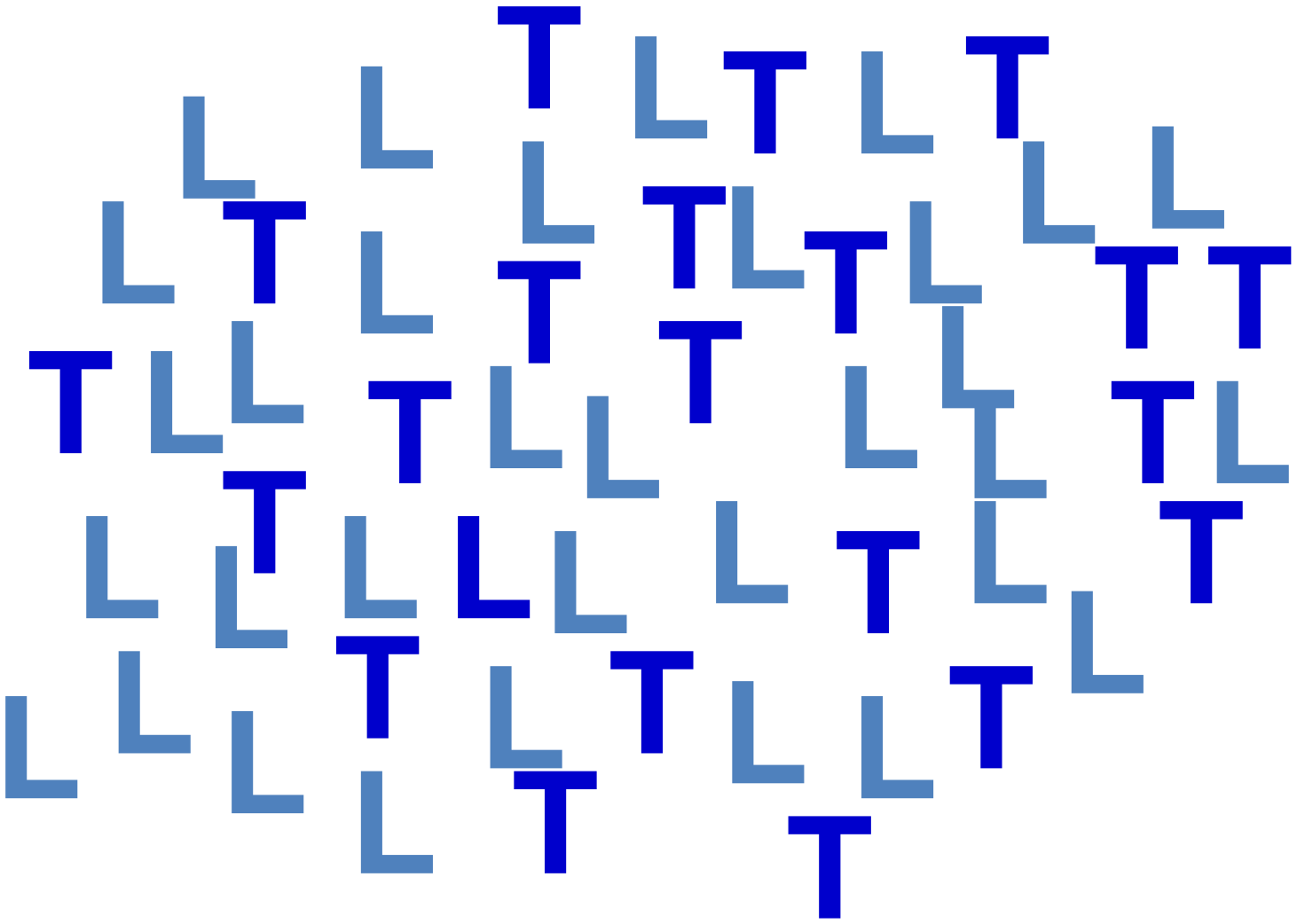
Find the vertical T



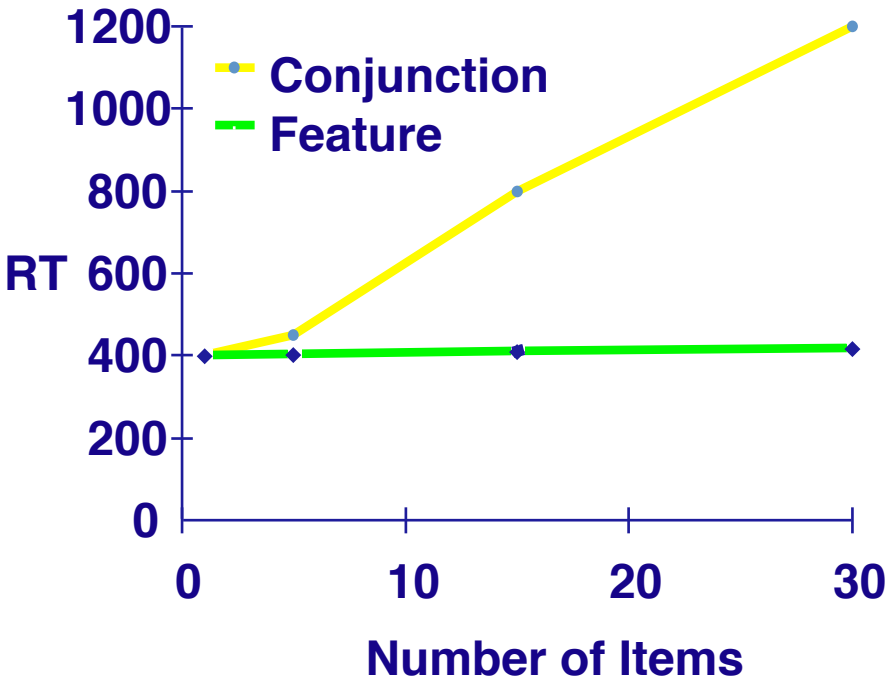
Find the Blue L

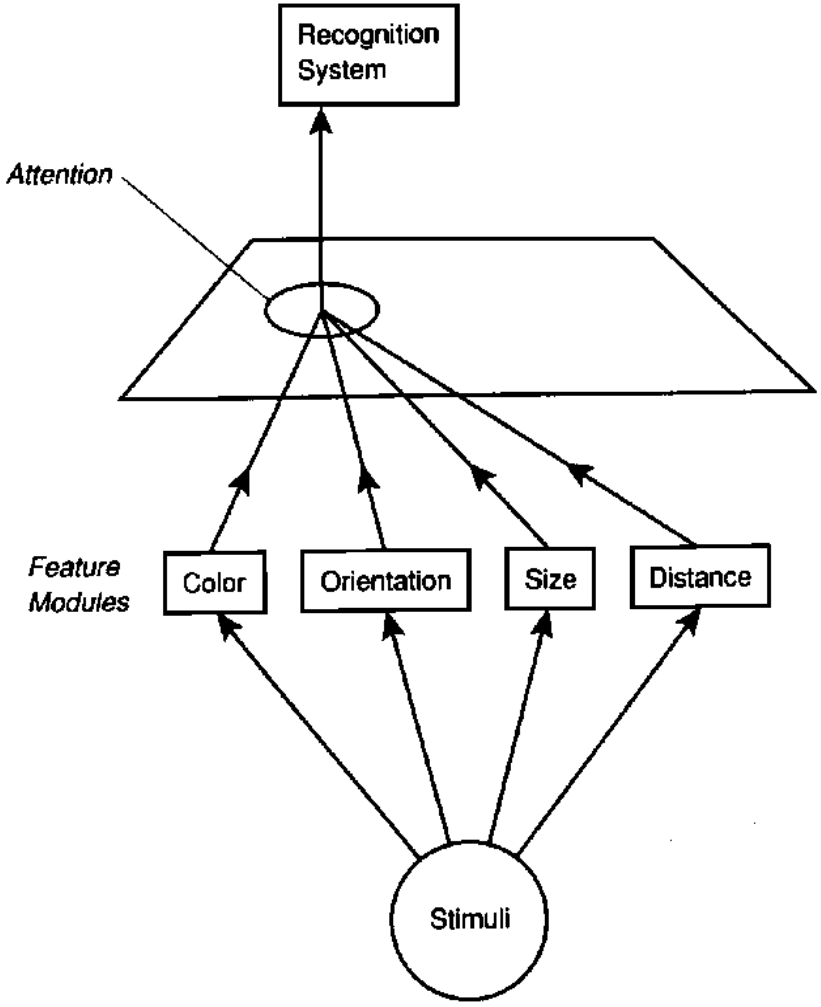


Find the Blue L

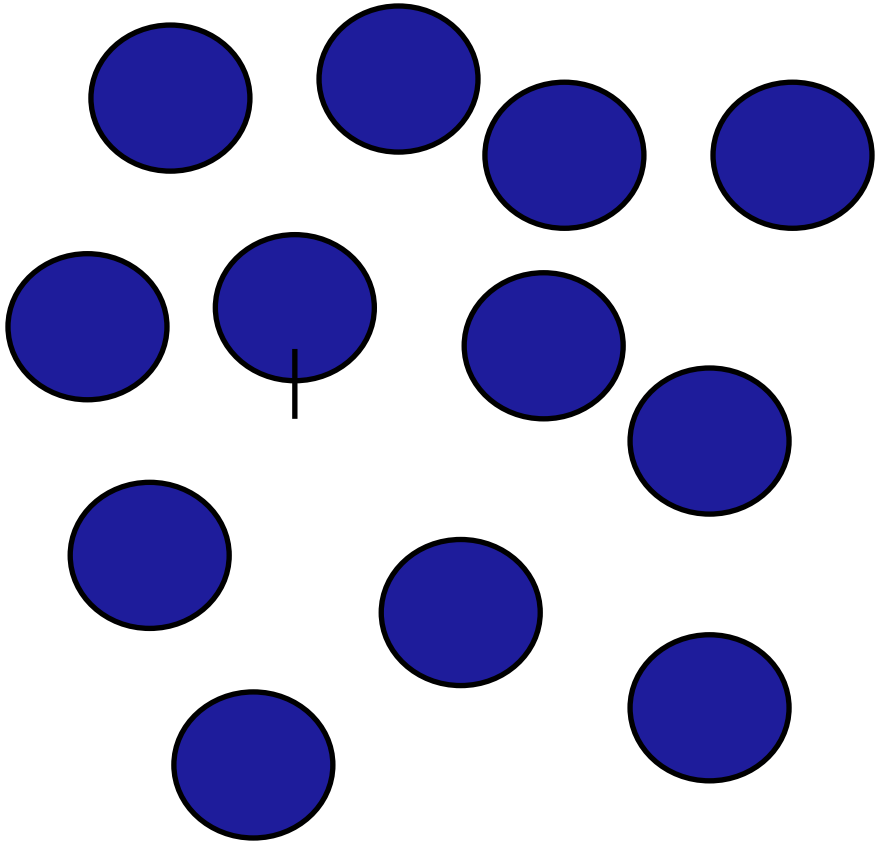


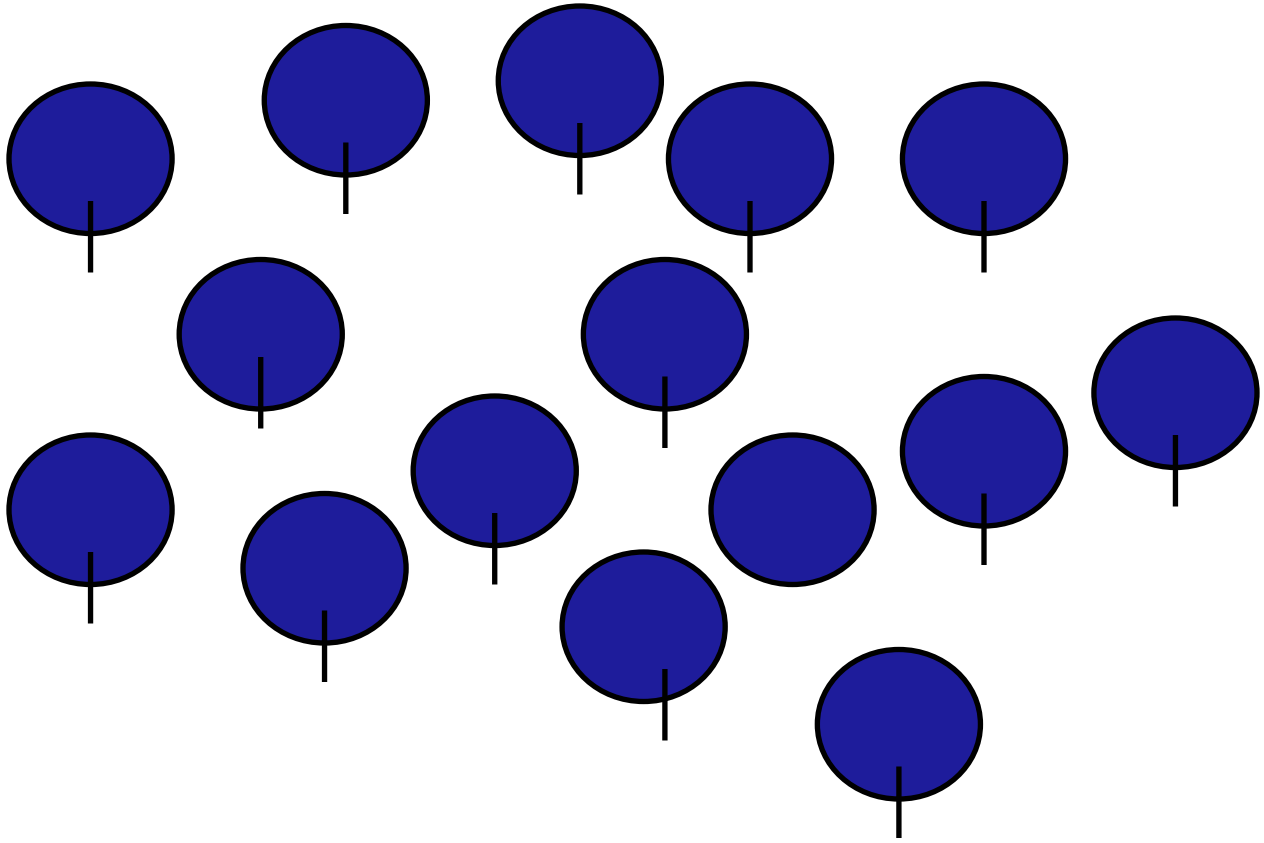
What's Going On?



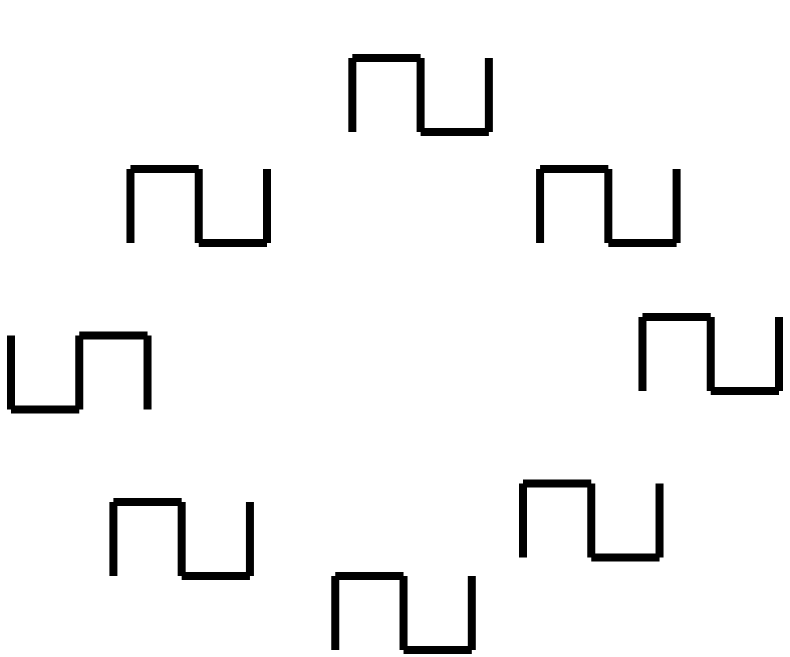


All Searches Are NOT Equal

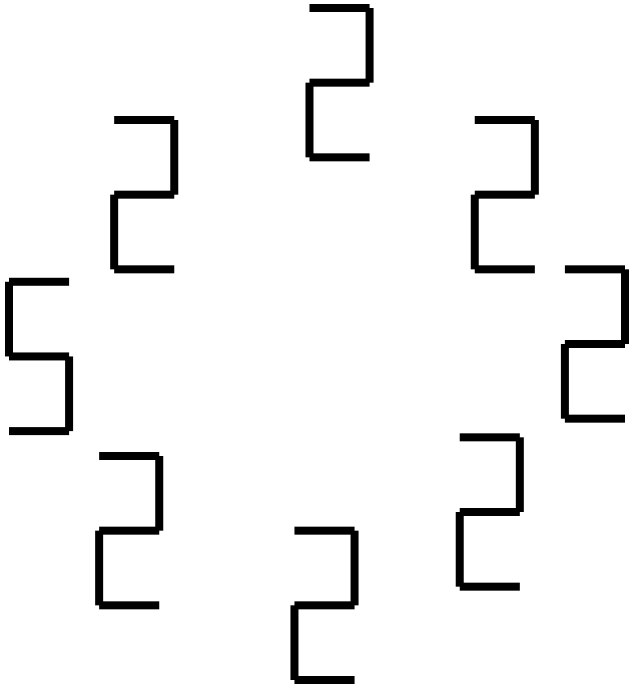




A Is More Difficult Than B

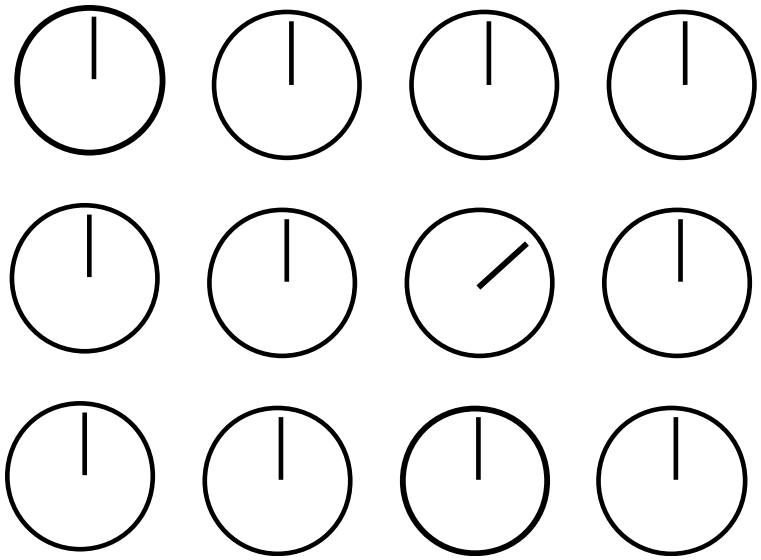


A

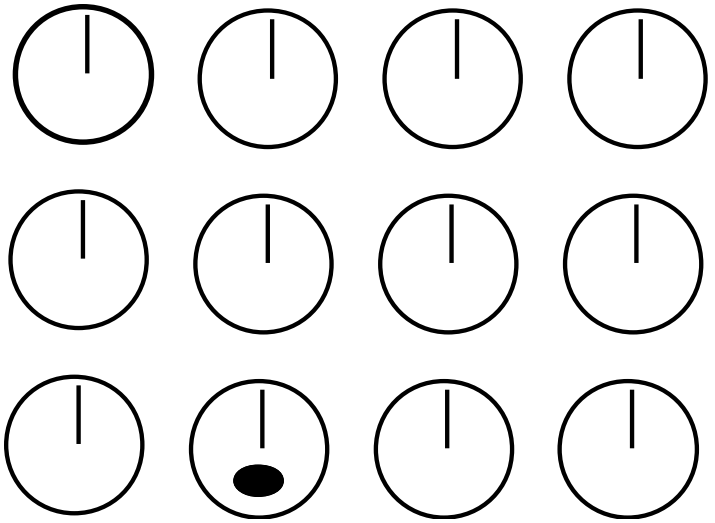


B

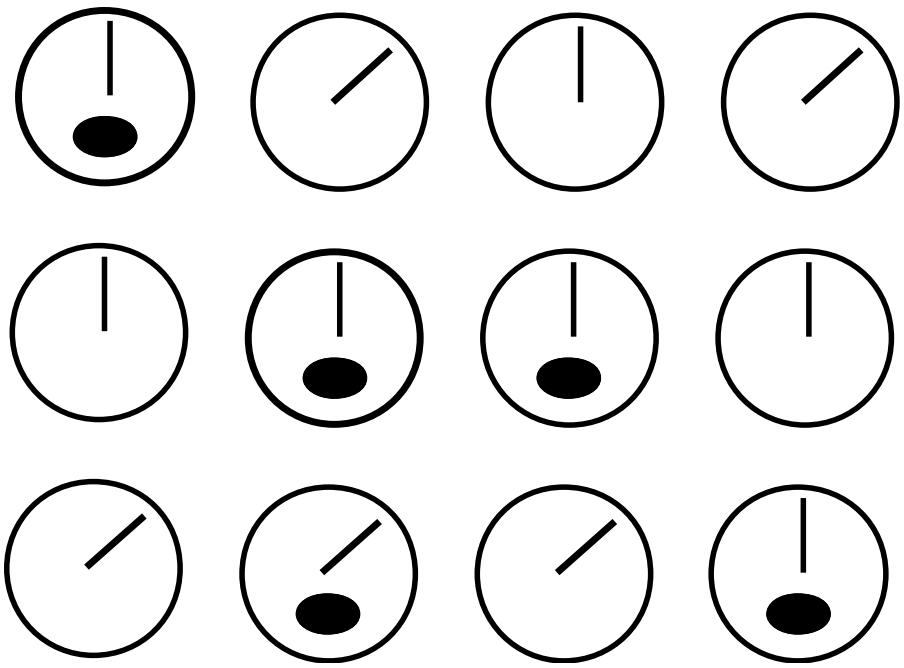
Why Is This Important?



Watch the Dial

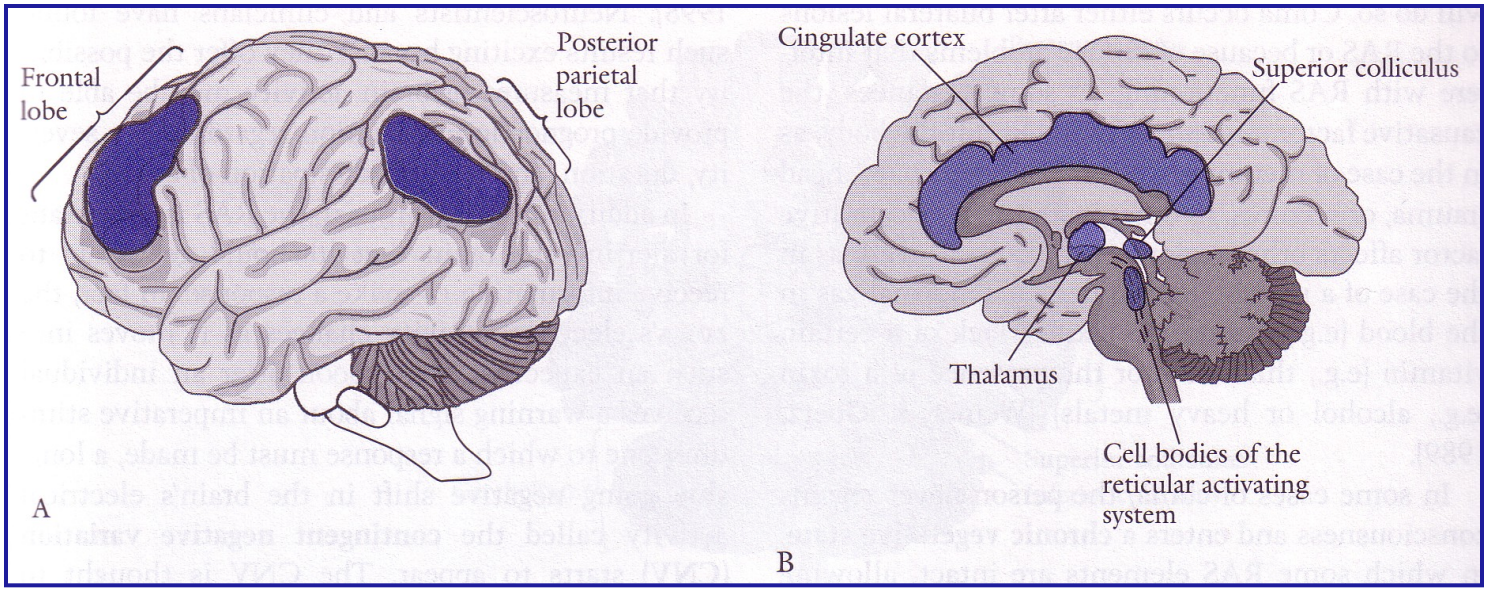


Watch for Light



Is There Trouble?

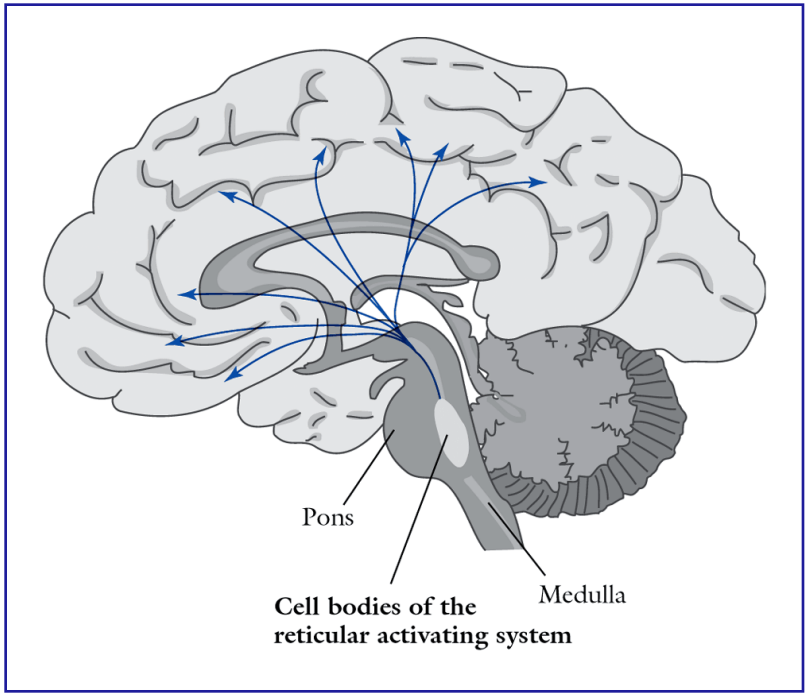
Neurophysiology of Attentional Matrix



1. **Reticular activating system**
2. **The superior colliculus**
3. **The thalamus**
4. **The parietal lobe**
5. **The frontal lobe**
6. **The cingulate cortex**

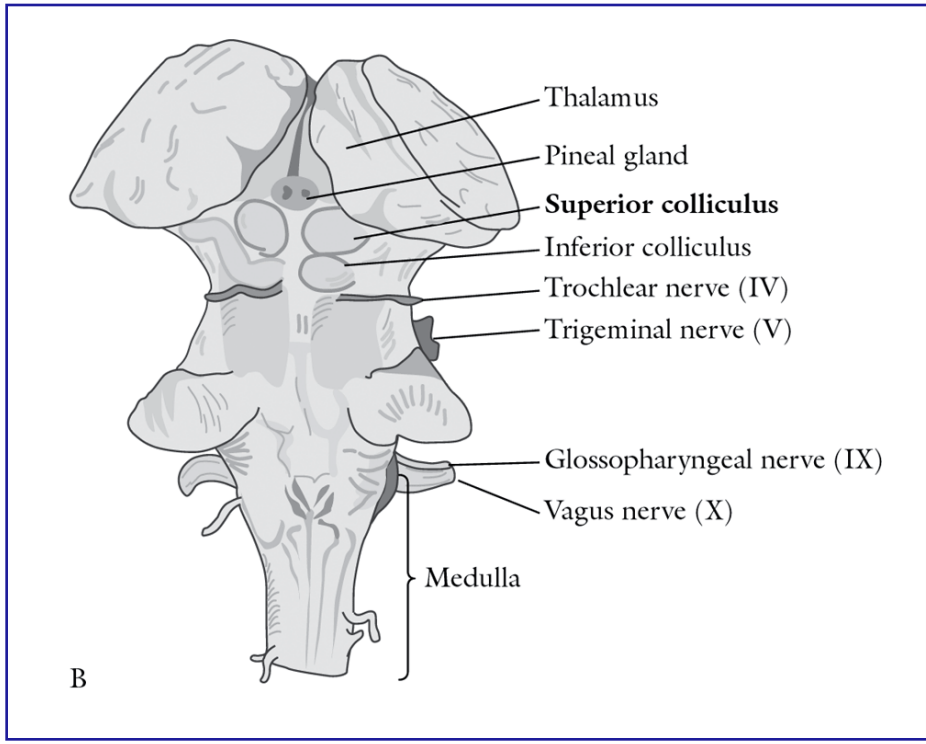
The Reticular Activating System (RAS)

- Arousal and wakefulness
- Sleep-wake cycle
- Cells in the reticular formation can set the pace of activity of cells throughout the brain
- Damage to the RAS can produce reduced attention – confusional state or coma
- Stimulants and depressants have an effect on this system



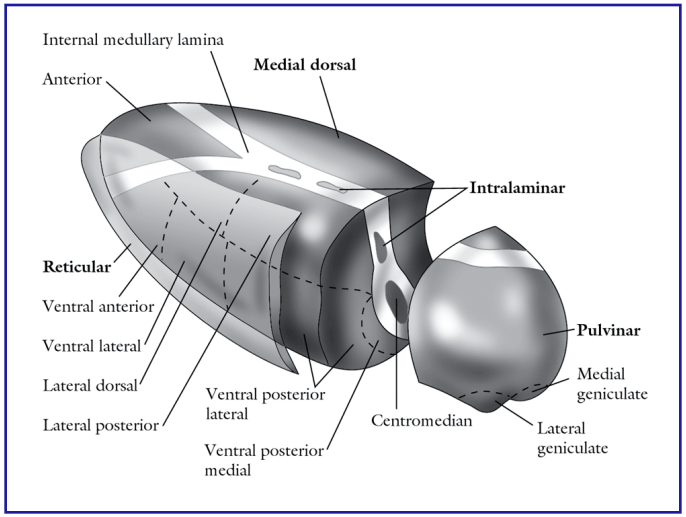
The Superior Coliculus

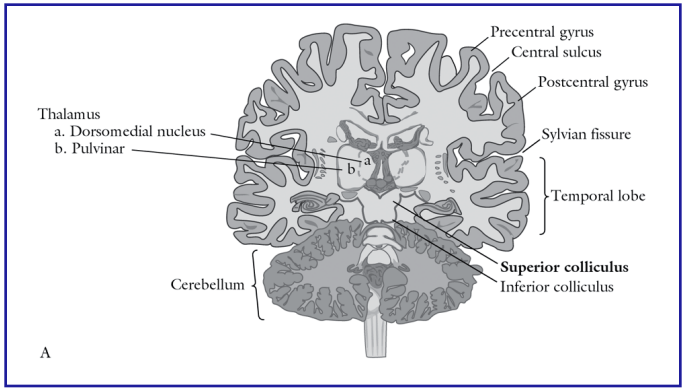
- This structure is important for directing *visual* attention to 'novel' stimuli
- **Saccade** – an eye movement in which the eyes jump from one position to the next (rather then moving smoothly)
- Express saccade – fast and reflexive in response to novel visual stimuli (superior coliculi)
- Regular saccade – voluntary eye movements (frontal eye fields)



Thalamus

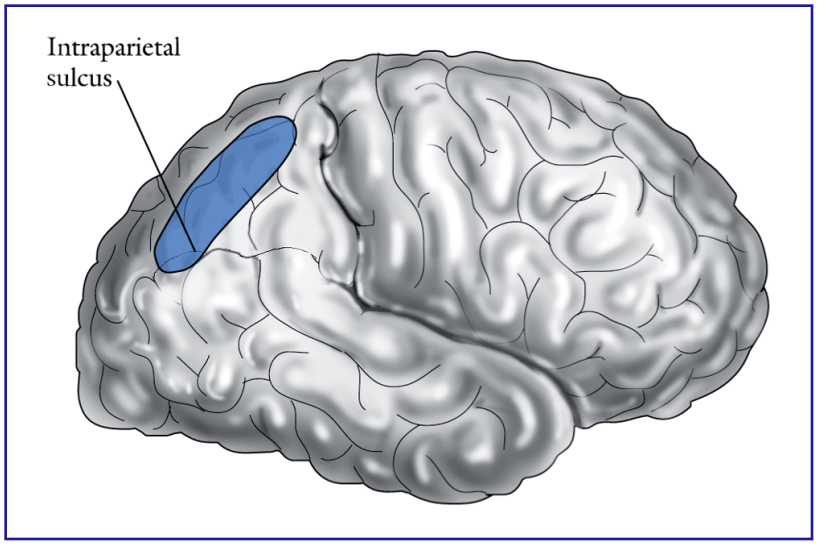
- Medial dorsal, intralaminar and reticular nuclei are important for general arousal (connected to the RAS)
- Pulvinar is involved in selective attention





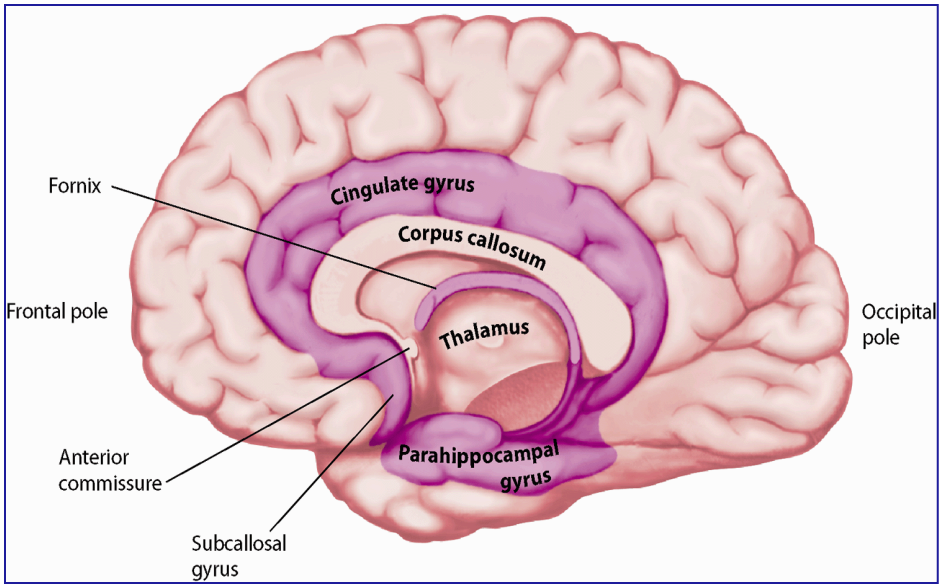
Parietal lobe

- Important for visual and spatial aspects of attention (remember the “where” pathway) and general attentional resources
- Domain-specific
- Top-down processing
- Hemineglect



Anterior Cingulate Cortex

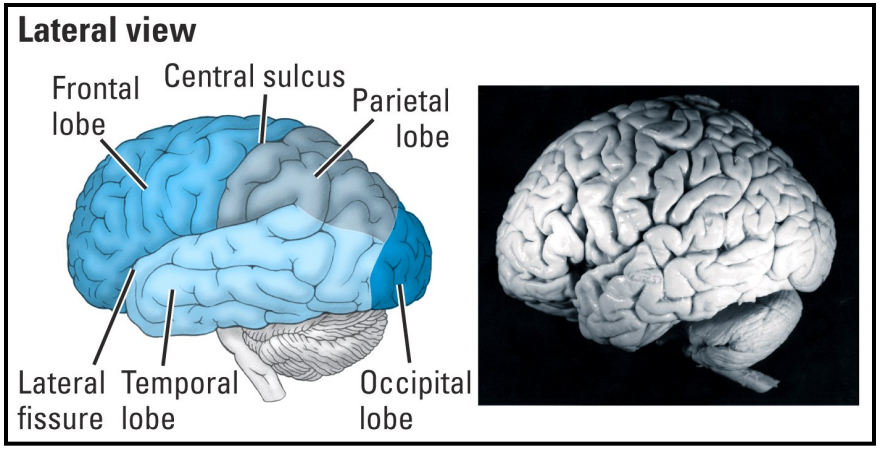
- Important for attentional selection



red	green	blue	yellow
blue	yellow	red	green
red	green	blue	yellow

Frontal Lobe

- Important for complex aspects of attention
- Executive control of attention → can inhibit the more reflexive aspects of attention
- Top-down processing
- Domain non-specific
- On-line holding of information

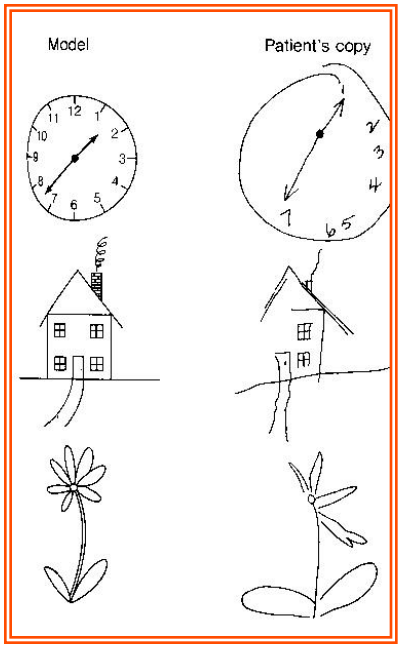


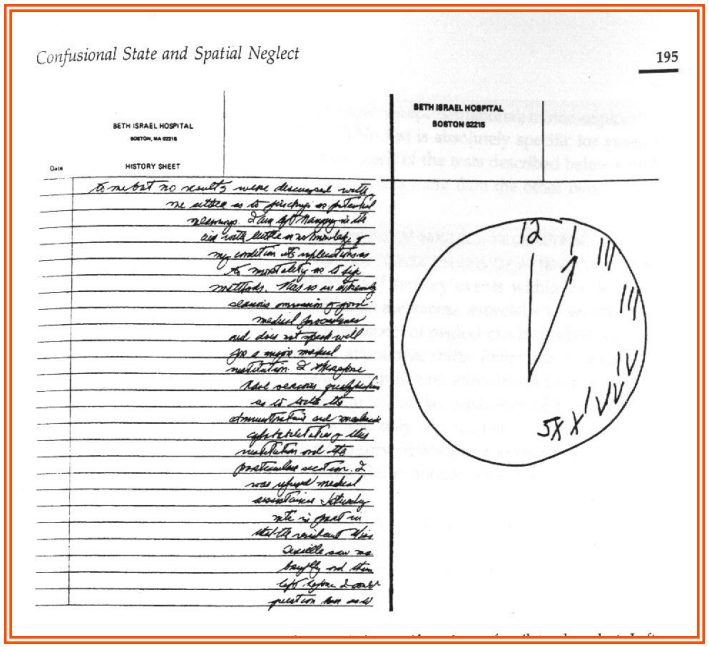
Hemineglect (Neglect)

- ***Neglect syndrome:*** the lack of attention to one side of space, usually the left, as a result of parietal damage
- Not attributed to a unitary deficit in arousal, orientation, representation, or intention

Clinical Features

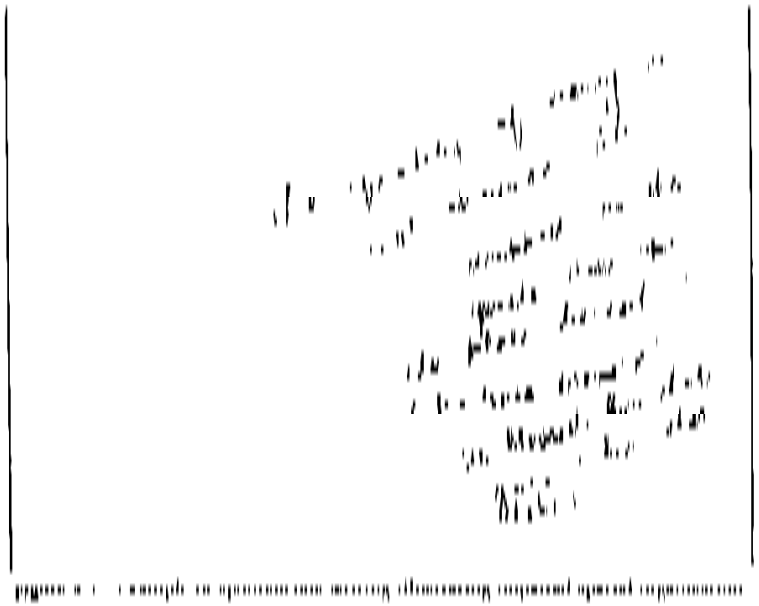
- Patients may shave, groom and dress one side of the body
- Patients may fail to eat food placed on left side of the plate





- Patients may fail to read the left side of words printed anywhere on the page
- In some cases neglect is more subtle

Their Visual Experience



Writing

Reading

On his way out of the town he had to pass the prison, and as he looked at the windows, whom should he see but William himself peeping out of the bars. And looking very sad indeed. "Good morning, brother," said Tom, "have you any message for the King of the Golden River?" William ground his teeth with rage, and shook the bars with all his strength, but Tom only laughed at him. And advising him to make himself comfortable till he came back again, shouldered his basket, shook the bottle of holy

Bisect All the Lines…

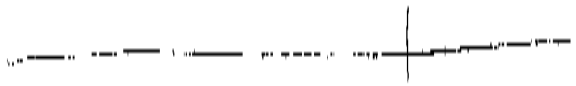


Fig. 10-2. Performance of patient with hemispatial neglect on line bisection task.

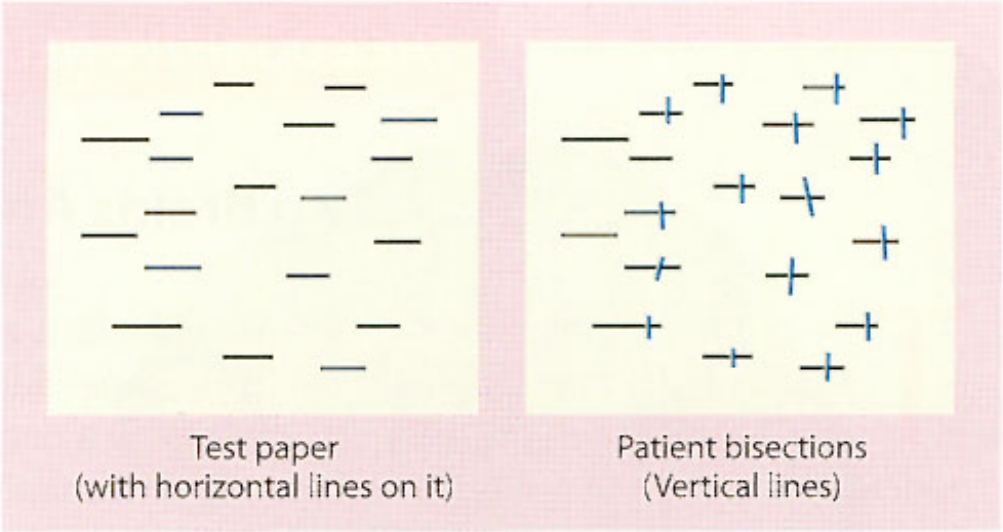
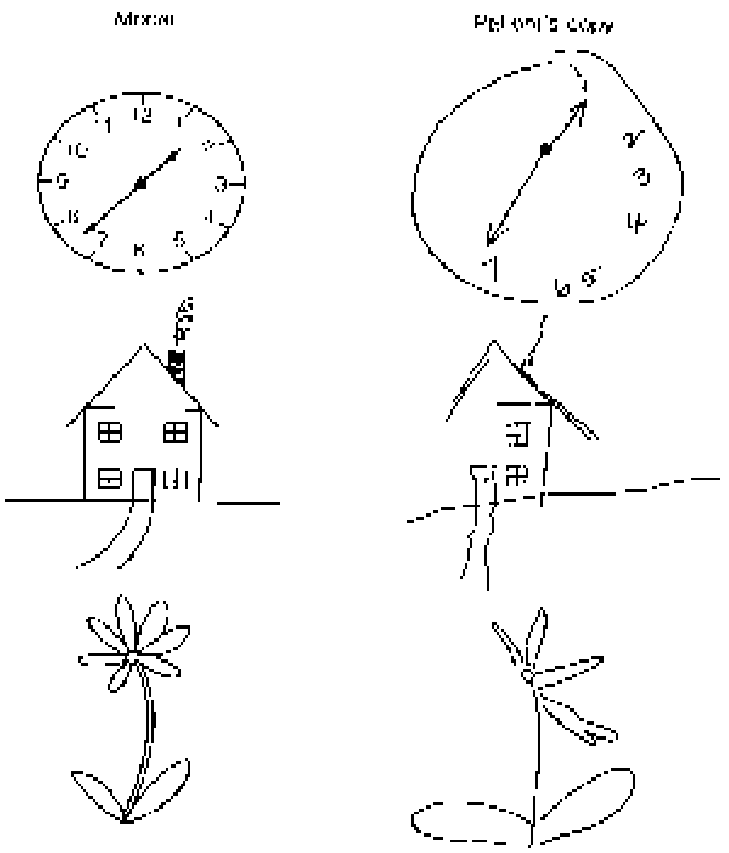


Figure 6.30 Patients suffering from neglect are given a sheet of paper containing many horizontal lines and asked under free-viewing conditions to bisect the lines precisely in the middle with a vertical line. They tend to bisect the lines to the right (for a right-hemisphere lesion) of midline due to neglect for contralesional space.

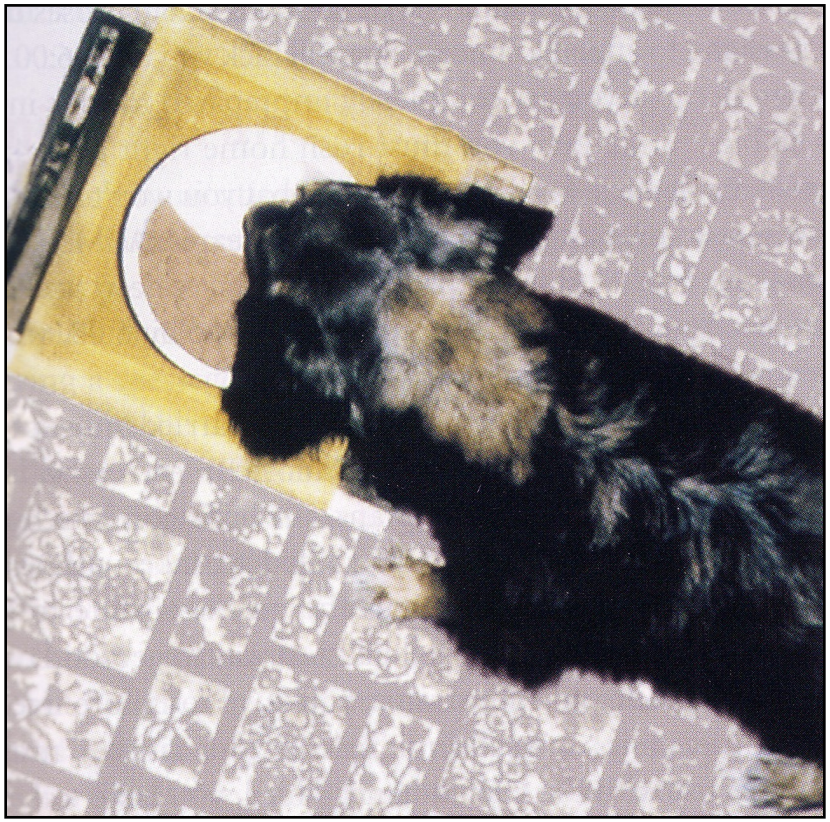
Drawings



Clinical Features

- Most dramatic and observable aspects of neglect occur in the visual sphere
- However, the phenomenon can be multimodal – patients may also display a rightward bias during detection of auditory, somatosensory, and even olfactory targets
- Many patients *may* also have hemianopia or hemiparesis

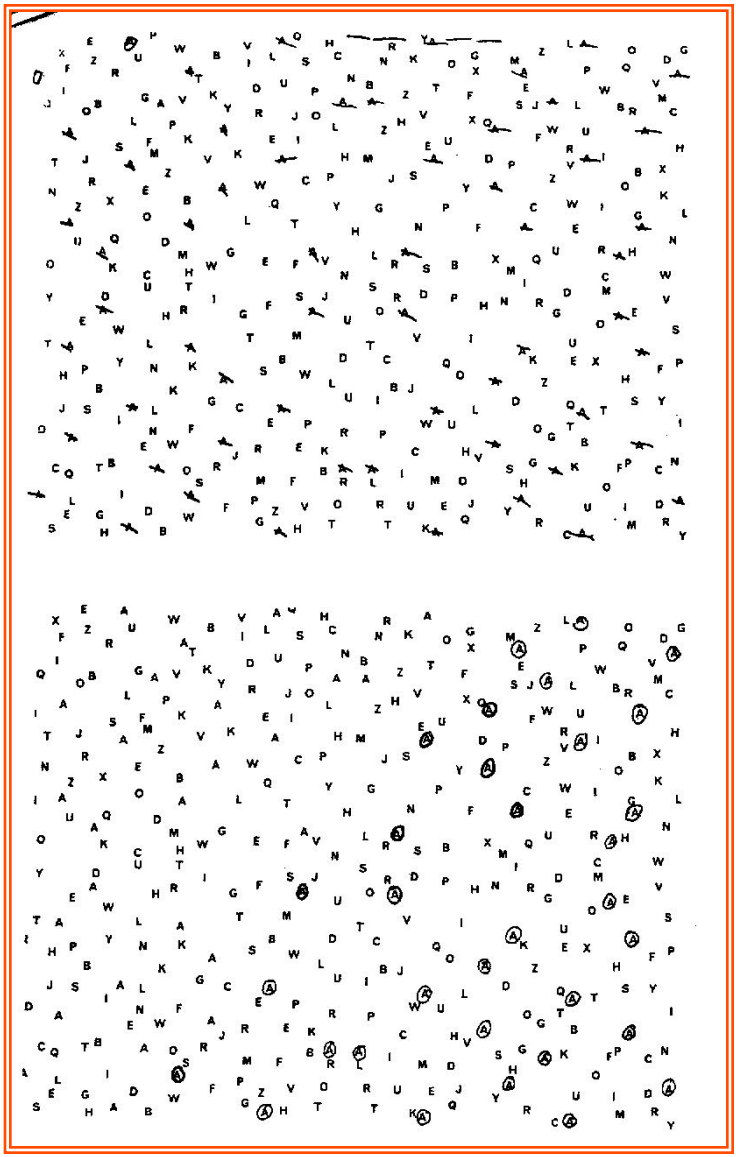
Neglect in Non-human animals



Is neglect due to sensory loss – hemianopia?

- Letter cancellation task
- Since some patients with hemianopia do not show neglect we can conclude that neglect is not due to hemianopia
- Hemianopia is <u>neither necessary nor sufficient</u> for the emergence of neglect

Patient has hemianopia but no neglect



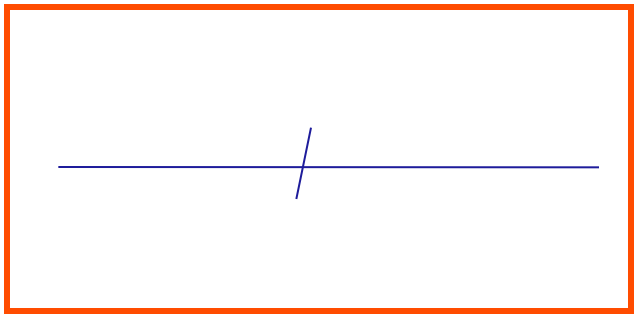
Patient shows neglect but has no hemianopia

Classification of Neglect Behaviors

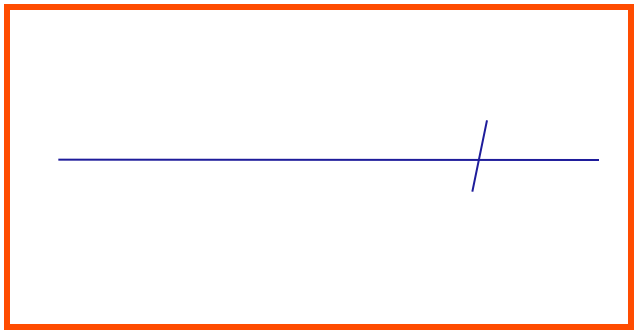
- Sensory-representational
- Motor-exploratory
- Limbic-motivational

Sensory-Representational Component of Neglect-Extinction
The Line Bisection Test

- Intact individuals place bisection mark slightly to the left of true centre
- Neglect patients place it rightward of the centre
- Patients with left hemianopia are like intact individuals
- If patients are asked to close their eyes and point to toward body midline, the patients usually point right of midline
- There is a shrinkage of the mental representation of the left hemispace (hallucinations, REM)



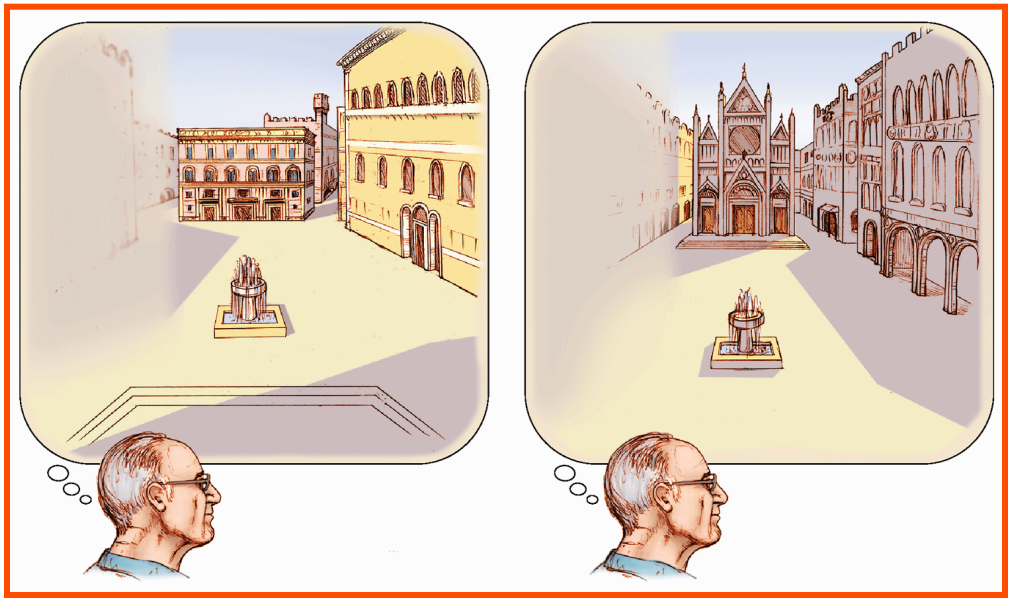
Intact



Left Neglect Patient

Sensory-Representational Component of Neglect - Internal Representations

- Left-neglect patients showe right side bias in their descriptions of memories
- Patient describing Piazza del Duomo
- The information is not obliterated
- Mental ‘spotlight’ fails to illuminate left-sided features



Unilateral Neglect and Memory

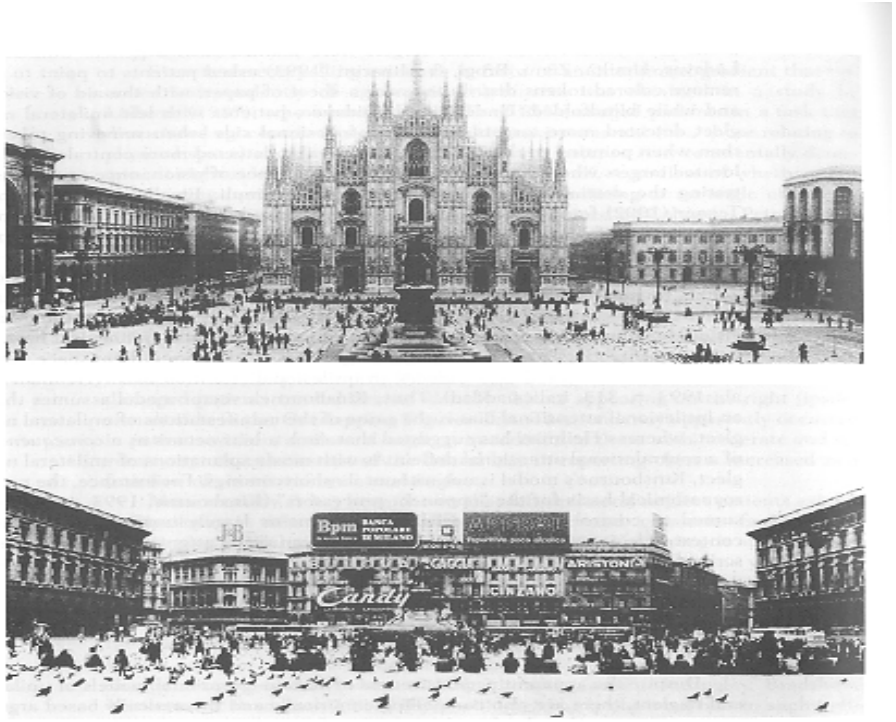


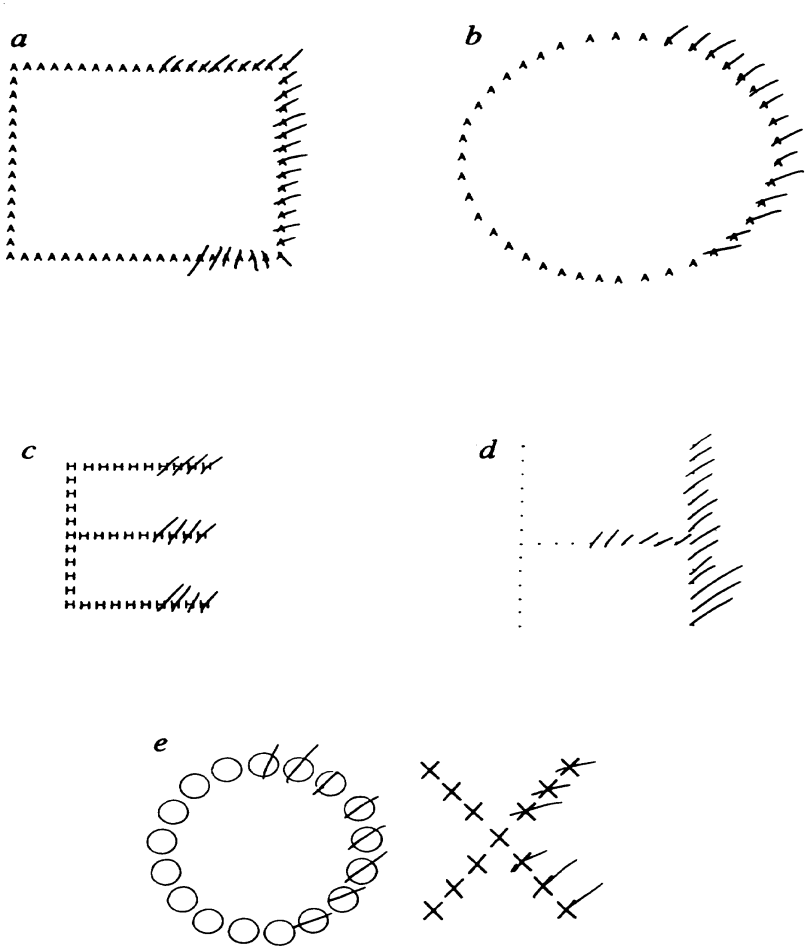
Figure 3 Facing the cathedral in the Piazza del Duomo in Milan (above), and looking across the square from the steps of the cathedral's main door (below). (From Bisiach & Berti, 1989).

Bisiach's patient (unable to recall half of the piazza del duomo) – representations are affected, not just acute visual input ("unilateral neglect of representational space")

What Causes Unilateral Neglect?

1. *Neglect results from damage to the attentional orienting system. Attention is mostly deployed to the right.*
2. *Neglect is caused by a failure to construct a complete mental representation of contralesional space.*

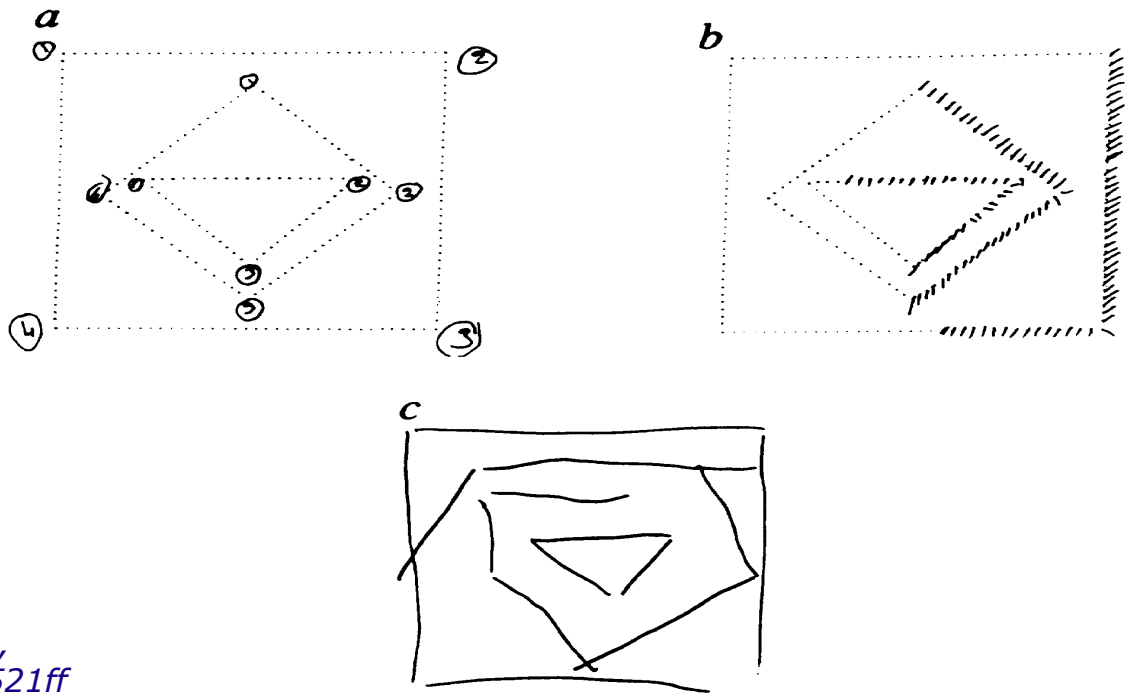
Unilateral Neglect: Patient J.R.



From Nature,
373, 1995, 521ff

Patient cannot completely cross out local components of global forms (Navon figures)

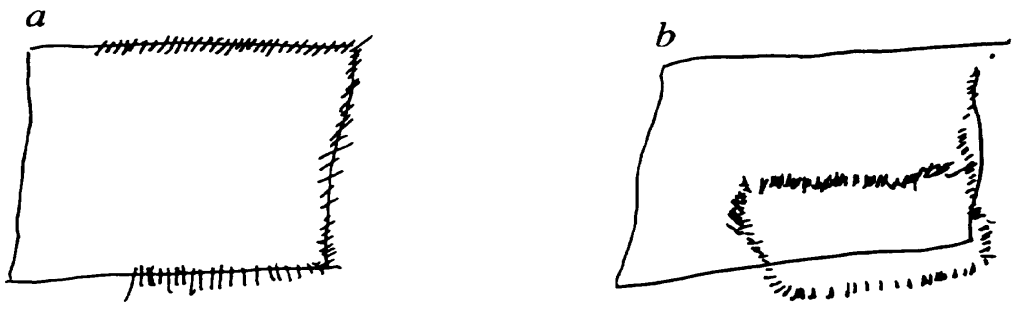
Unilateral Neglect: Patient J.R.



From Nature, 373, 1995, 521ff

However, patient <u>can</u> adequately describe the figure shown in (a) and mark its corners; patient then <u>cannot</u> cancel all the dots (b); patient <u>can</u> reconstruct figure from memory (c).

Unilateral Neglect: Patient J.R.

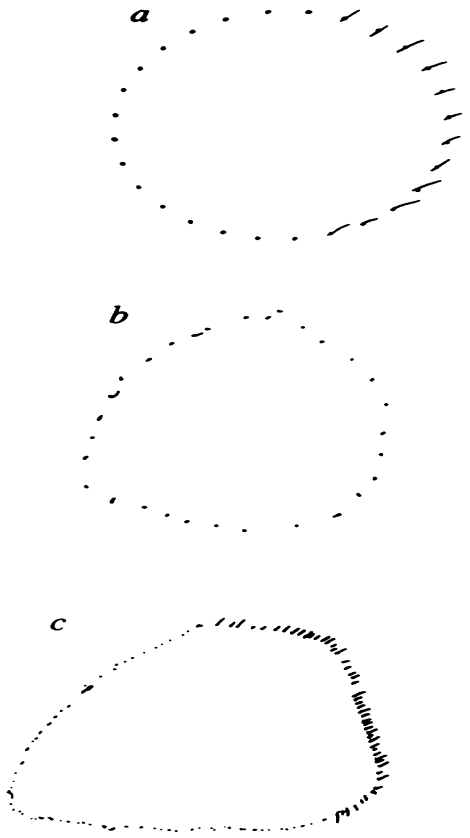


From Nature, 373, 1995, 521ff

Patient cannot cancel all imaginary components of a drawn square (a); performance is better without vision (blindfolded) (b).

Note the contrast between exogenously (input) driven and endogenously (memory) driven task!

Unilateral Neglect: Patient J.R.

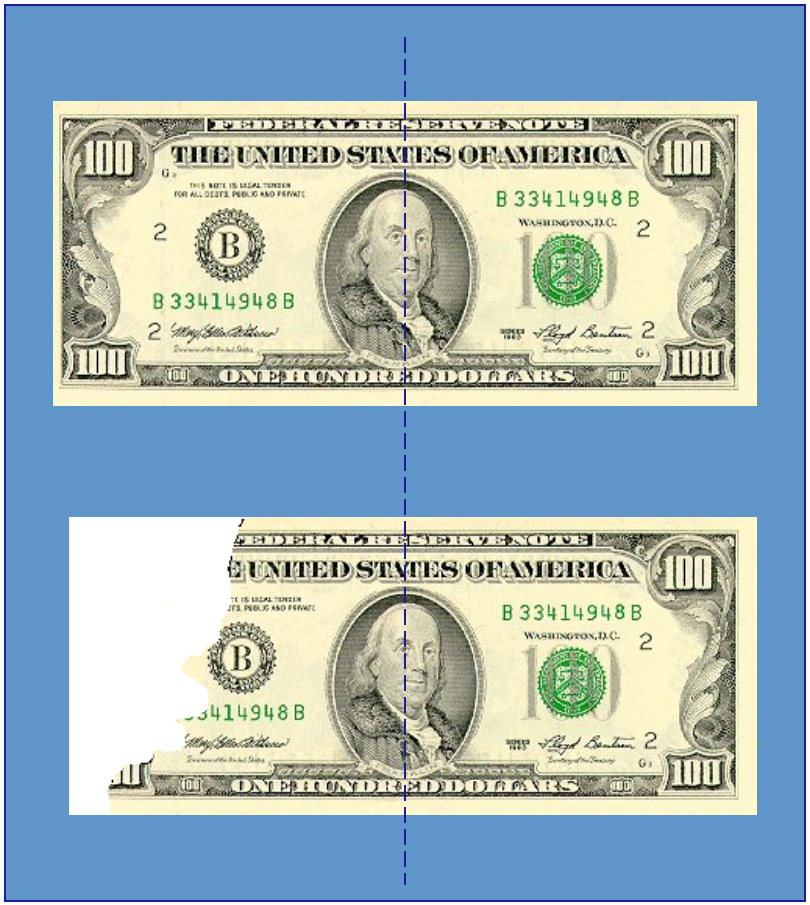


From Nature, 373, 1995, 521ff

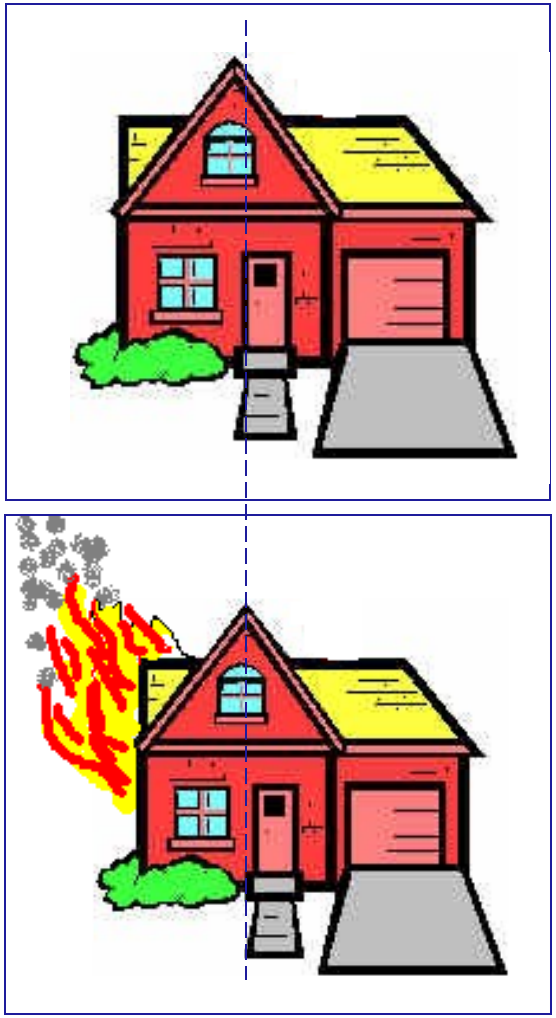
Patient cannot cancel all dots in (a), but can reproduce a circle of dots (driven by an internal global representation) (b). After drawing the circle, again dots cannot be canceled on the left (c).

- At what level do patients ignore the stimuli on the left (peripherally or centrally; early-selection or late-selection deficit)?
- How would you test this?

Are these two the same?



Are these two the same?



The Gating in Neglect is Central, Not Peripheral – Implicit Processing

LATE SELECTION

Determinants of Neglect

- **Egocentric**
  (with respect to the observer)
- **Allocentric**
  (with respect to another extrapersonal event)
- **Object-centered**
  (with respect to a principal axis in the canonical representation of an object)

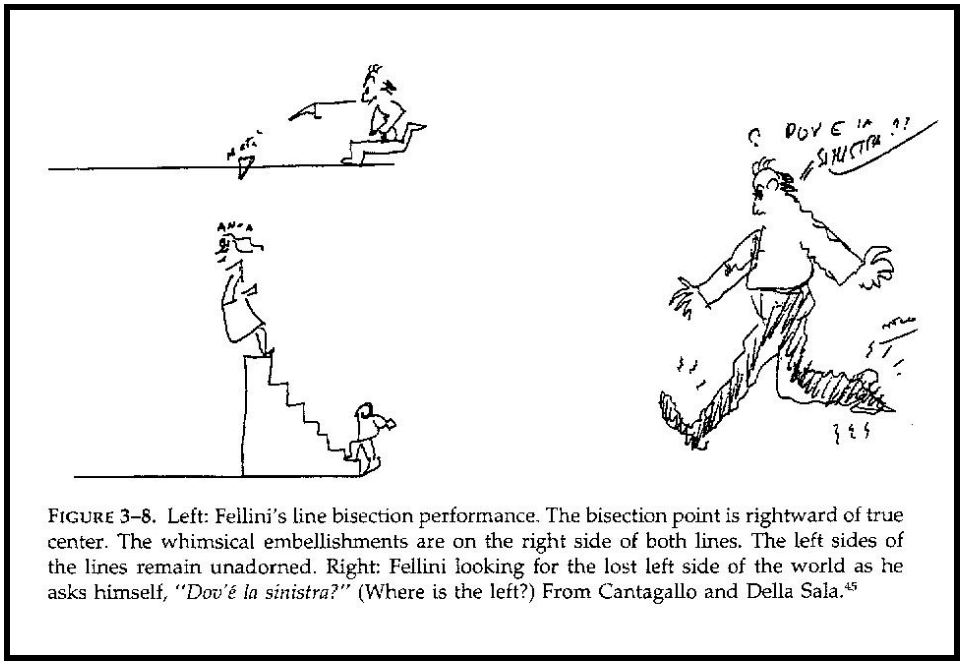
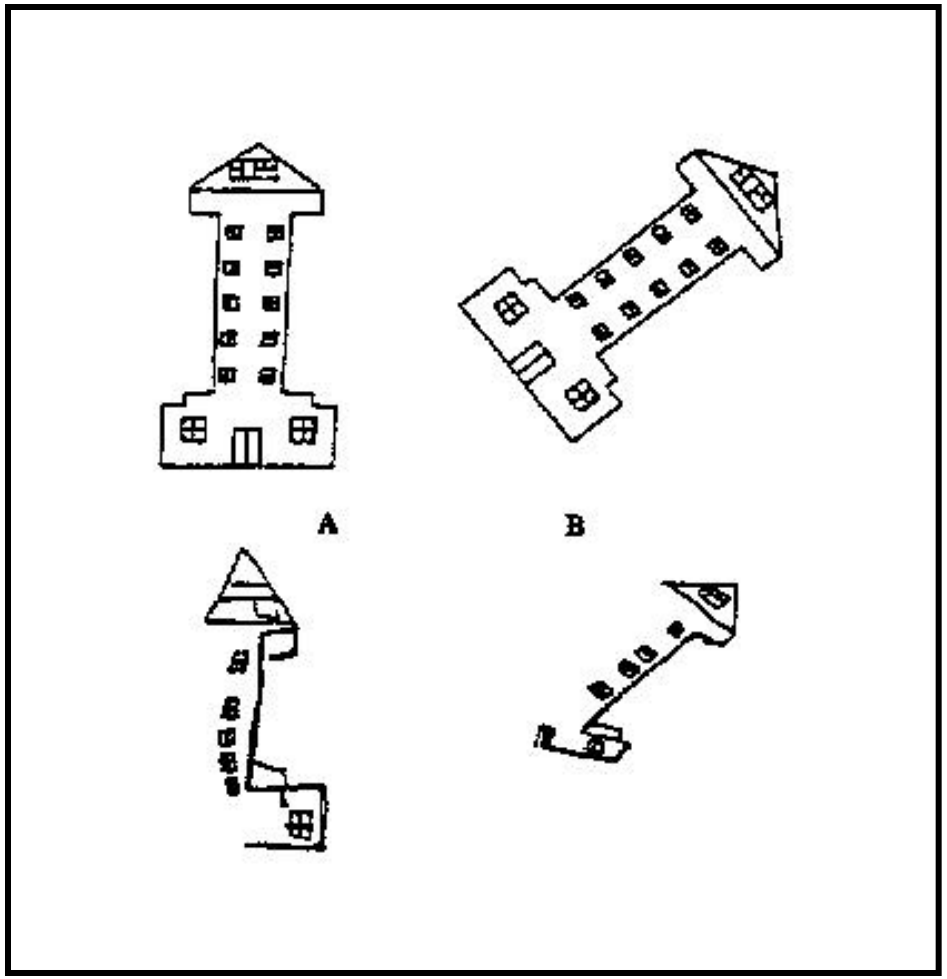


FIGURE 3–8. Left: Fellini's line bisection performance. The bisection point is rightward of true center. The whimsical embellishments are on the right side of both lines. The left sides of the lines remain unadorned. Right: Fellini looking for the lost left side of the world as he asks himself, *"Dov'é la sinistra?"* (Where is the left?) From Cantagallo and Della Sala.[45]

Federico Felini: Dov'é la sinistra?

Object-Based Coordinates

- "Leftness" is relative



Far-Space Versus Near-Space

- Some patients have left neglect only for the near-space within an arm's reach
- Some patients have left neglect only for events in far-space, beyond arm's reach
- Some patients show a "peripersonal" neglect of the body
- ***Anosognosia*** **–** loss of ability to recognize or acknowledge an illness or bodily defect (delusion that the paralyzed limb belongs to someone else)
- Sacks (The Man Who Fell out of Bed)

Recovery

- A number of patients show recovery in the weeks following injury
- 50% of patients recover – 9 to 43 weeks

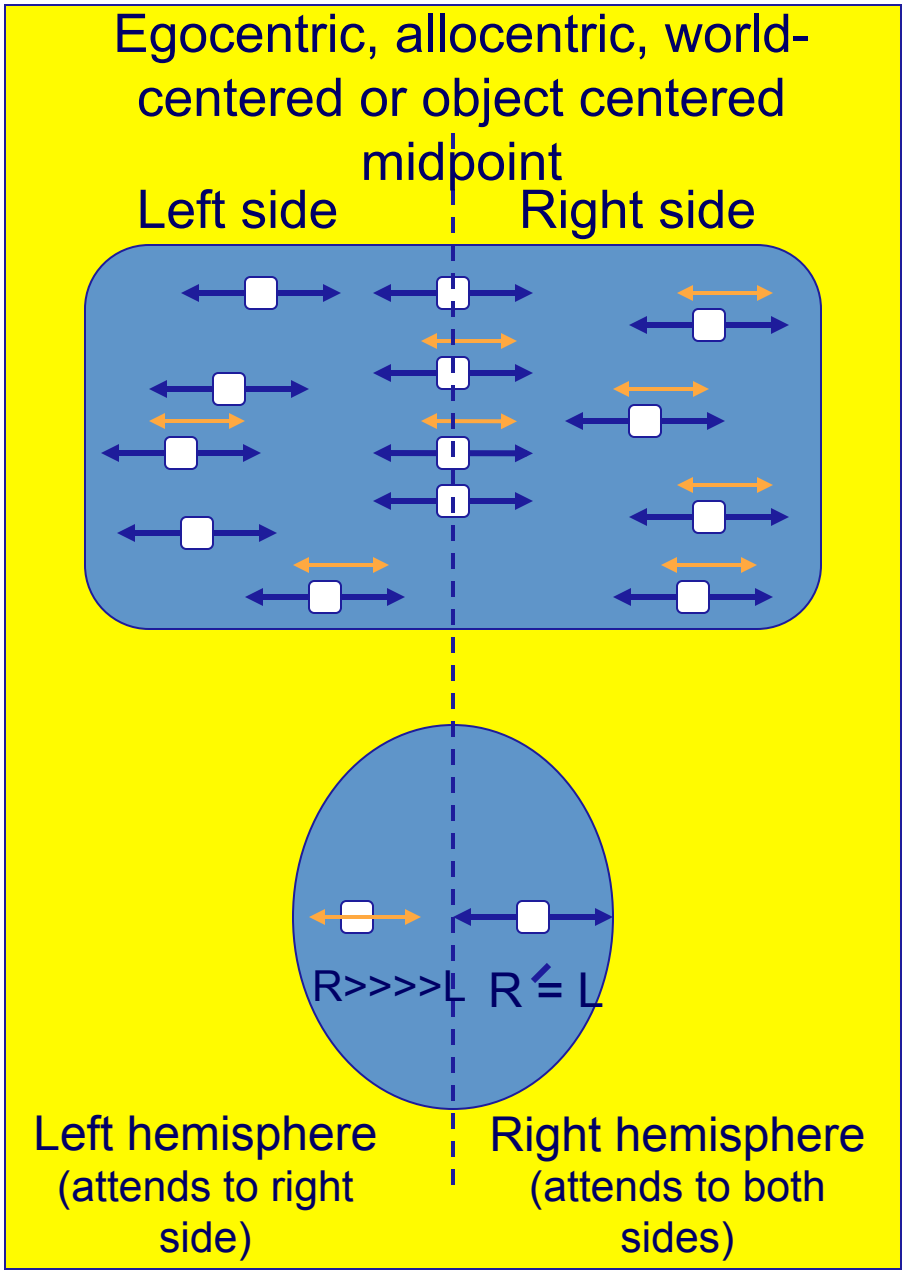
Right Hemisphere Dominance For Spatial Attention

- Clinical evidence – contralesional neglect is more frequent, severe, and lasting after right hemisphere lesions
- Why is this the case?

1. The left hemisphere attributes salience predominantly to the right side of events (shifts attention mostly in rightward direction)

2. The right hemisphere attributes salience to both side of events (distributes attention and shifts attention both left and right)

3. The right hemisphere devotes more neuronal resources to spatial attention and attentional tasks

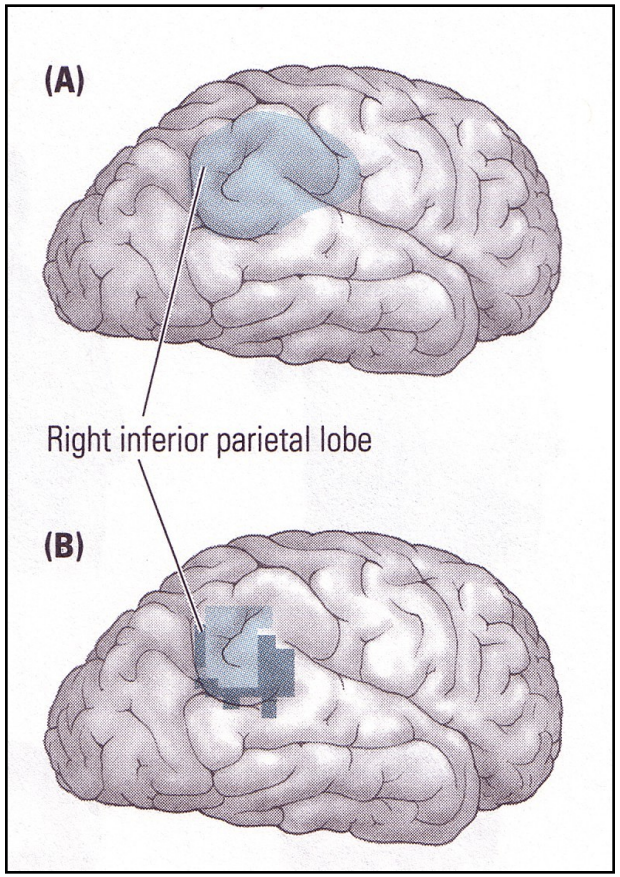


Evidence for Right Hemisphere Role in Spatial Tasks

- EEG evidence during spatial tasks
- fMRI evidence during spatial tasks
- The left hemisphere attends only to the contralateral right hemispace whereas the right hemisphere attends to the entire extrapersonal space

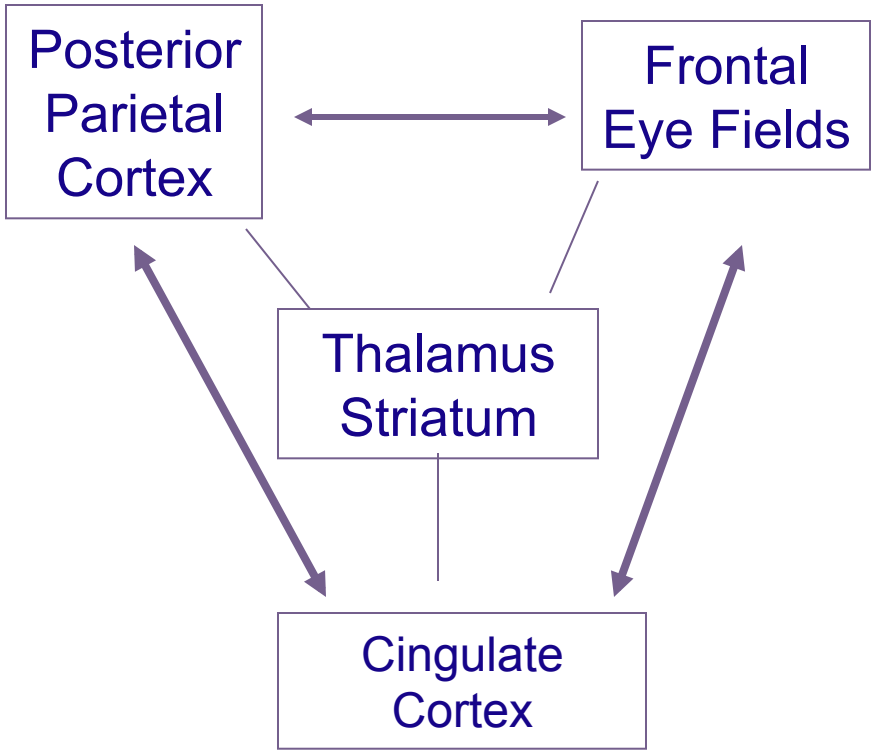
Functional Anatomy of Unilateral Neglect

- Evidence based on multilobar infracts, major head trauma or large neoplasams
- Traditional view – damage to the ***right inferior parietal lobe*** will produce unilateral neglect
- New evidence also implicates frontal lobes, cingulate gyrus, striatum and thalamus



Functional Anatomy of Unilateral Neglect

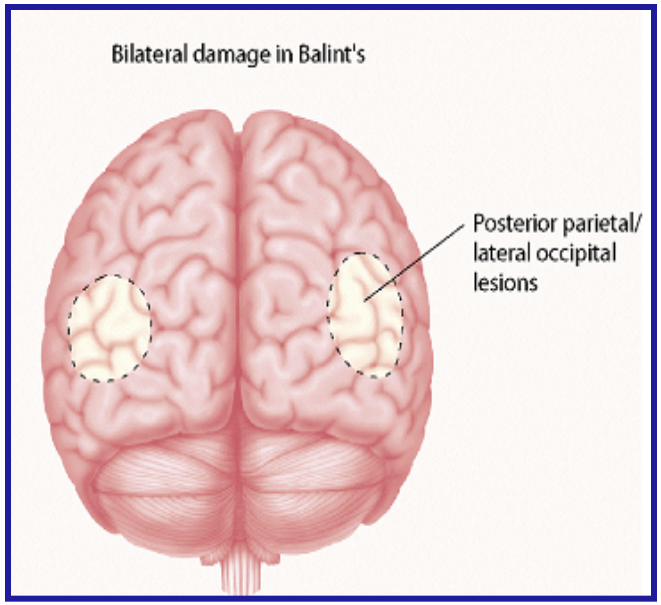
- Unilateral neglect is not a “parietal syndrome”, rather it is an “attentional network syndrome”
- Parietal “sensory” neglect
- Frontal “motor’ neglect

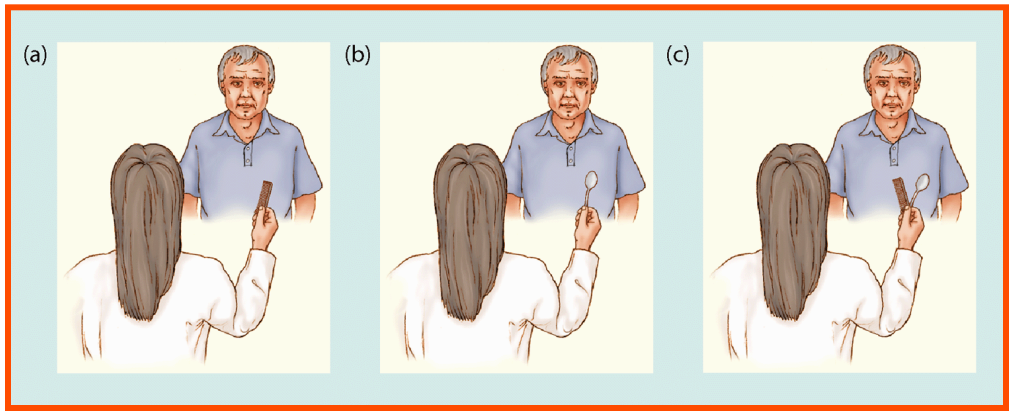


Posterior Parietal Deficits - Balint's Syndrome

1. Paralysis of eye fixation with inability to look voluntarily into the peripheral visual field
2. Disturbance of visual attention such that there is neglect of the peripheral field (only one object perceived at the time - **simultagnosia**)

- **Optic ataxia**
- Anosognosia



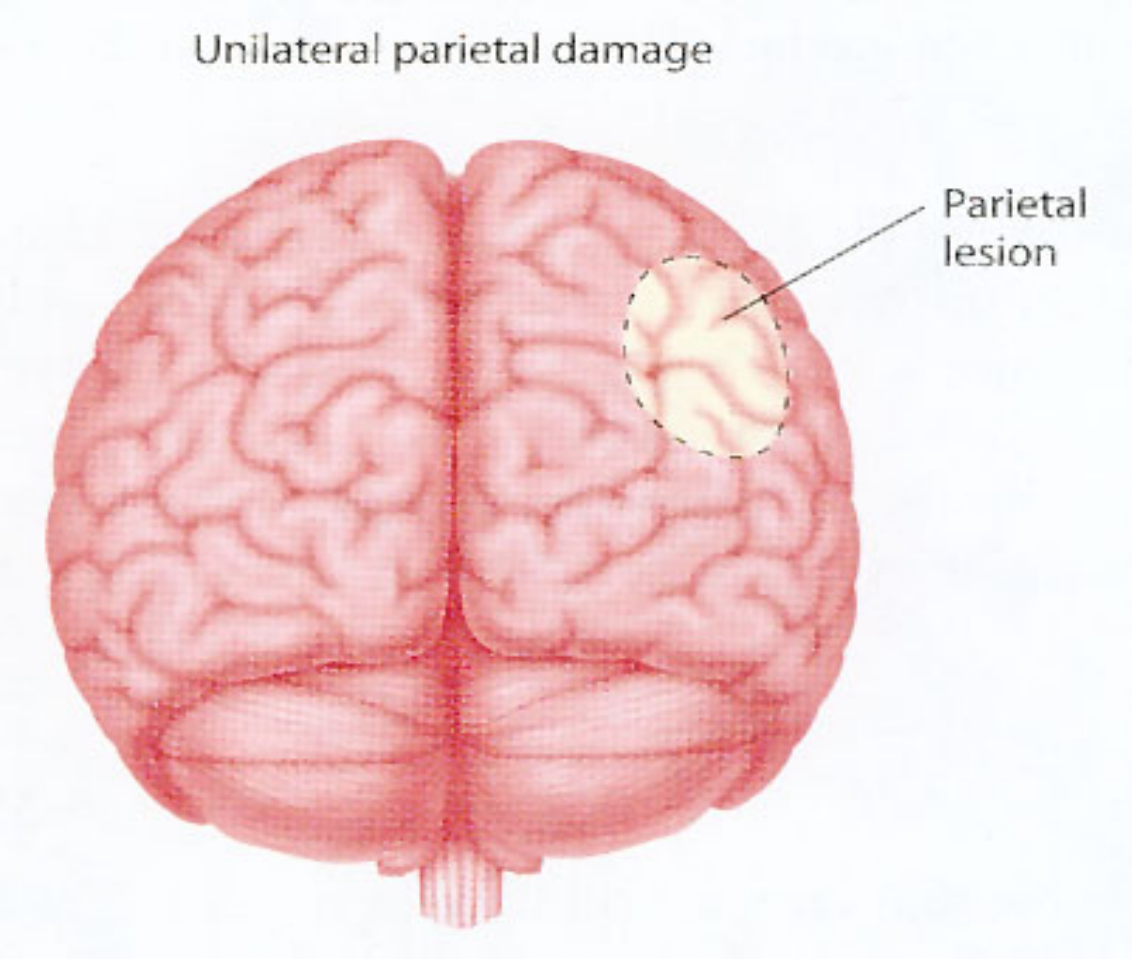


Hemineglect

- Bisiach & Luzatti (1978)
  - Have patients image standing at one end of piazza and describe what they see
  - Can only describe buildings on the right, even when they imagine facing the opposite way (what they had previously omitted!)
  - Neglect occurs for internal mental representations

When Attention Is Lost

Visual Neglect



Additional slides

Two Disorders of Attention

Unilateral neglect

Balint syndrome

Symptoms of Unilateral Neglect

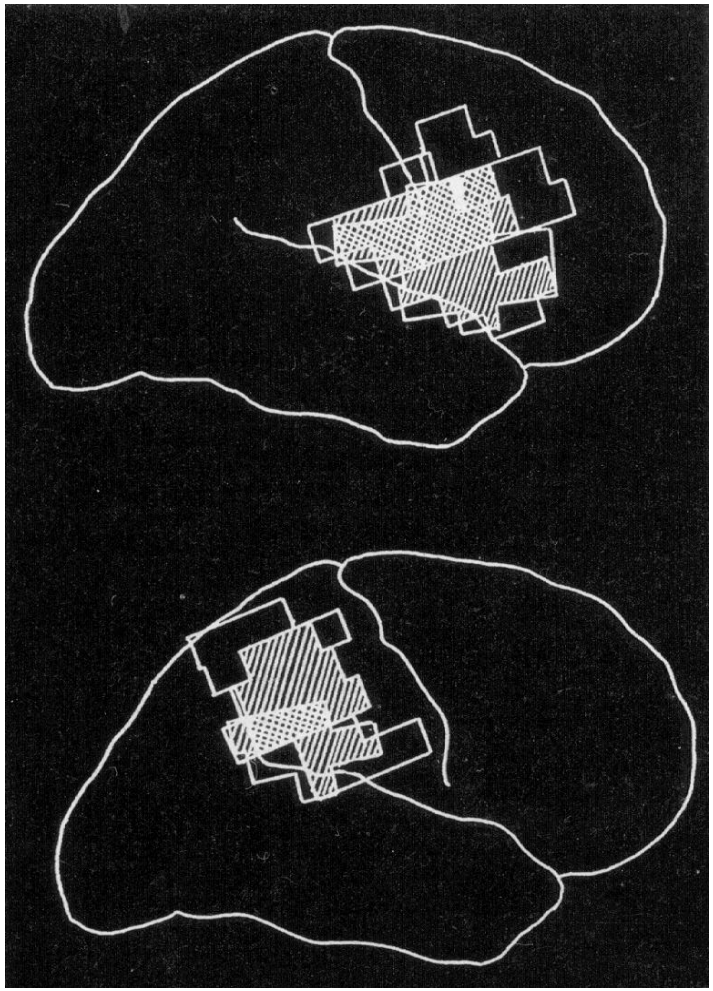
- *left hemiparetic arm*
- *anosagnosia- unawareness / denial of illness.*
- *rightward gaze deviation*
- *no obvious hemianopia*
- *Visual extinction to double simultaneous stimulation (DSS)*
- *Tactile extinction to DSS*
- *Constructional apraxia: deficit in constructional and drawing tasks*
  - *apraxia: disorder of skilled movement*
- *allesthesia: (gross) mislocalization of stimulation*

Unilateral Neglect

- *A deficit in perceiving and responding to stimulation on one side.*
- *Not a visual or motor defect (hemianopia or hemiparesis)!*
- *Two components: spatial neglect, bodily neglect.*
- *Typical lesion site: unilateral parietal-occipital junction, (dorsal) parietal cortex (Brodmann's area 7, 40)*
- *Side opposite to lesioned hemisphere (contralesional side) is affected.*

Unilateral Neglect: Lesion Sites

Lesion sites (frontal and parietal) from 7 patients with left-sided neglect



Husain et al., Nature 385, 154, 1997

Unilateral Neglect

Behavioral components of unilateral neglect:

1. *Perceptual component: sensory events on one side have diminished impact on awareness (extinction).*

2. *Motor component: hemispatial exploratory weakness (manual exploration tasks)*

3. *Motivational (limbic) component: "nothing important is expected to be happening" on the affected side.*

Unilateral Neglect

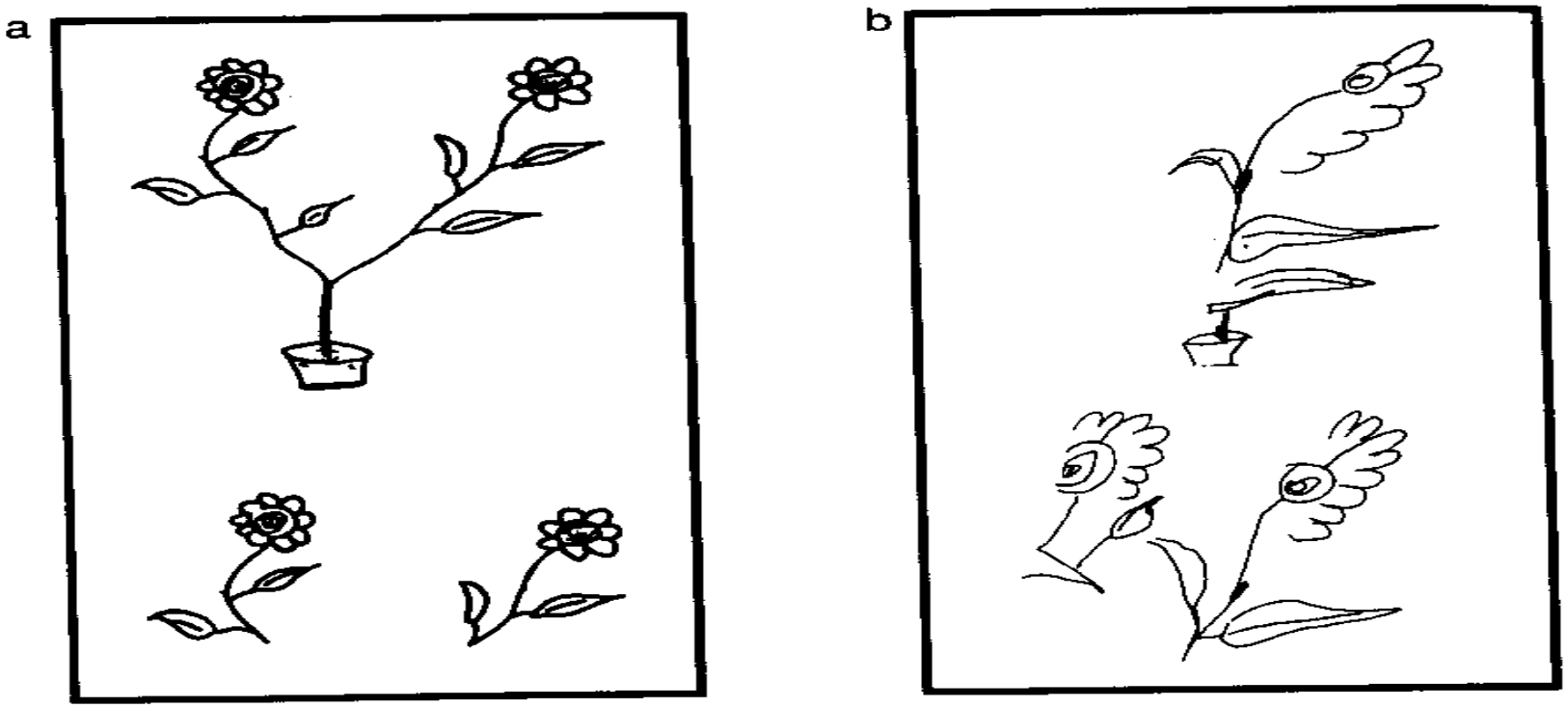
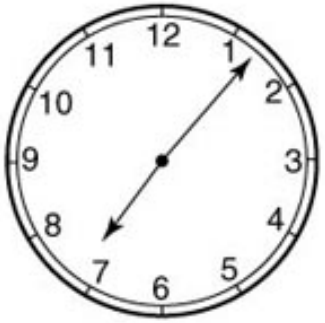


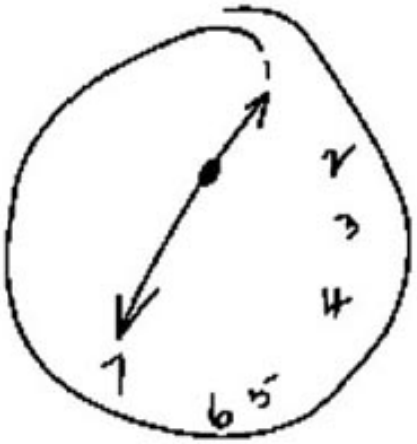
Figure 7 (a) EXAMINER'S MODEL OF TWO FLOWERS DEPICTED EITHER AS PARTS OF A SINGLE OBJECT (ABOVE) OR AS TWO SEPARATE OBJECTS (BELOW). (b) COPIES BY A PATIENT WITH LEFT UNILATERAL NEGLECT. (FROM MARSHALL & HALLIGAN, 1993.)

Unilateral Neglect

Model



Patient's Drawing



Model

Patient's Drawing

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Unilateral Neglect

Unilateral Neglect

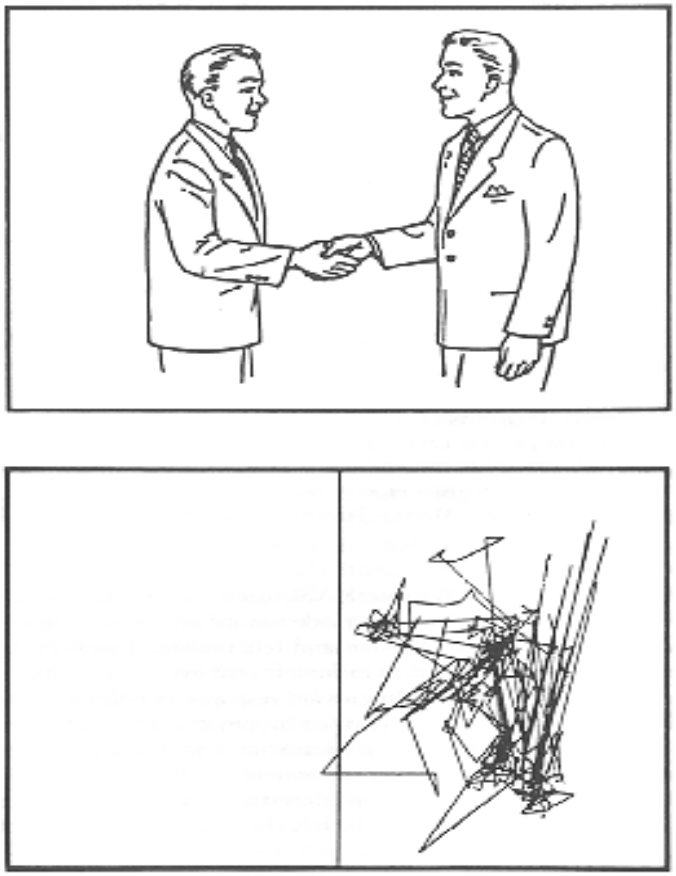

Figure 6 EYE MOVEMENT TRACINGS (BELOW) FROM A PATIENT WITH LEFT UNILATERAL NEGLECT, DURING VISUAL EXPLORATION OF A LINE DRAWING (ABOVE). (FROM KARNATH, 1994A.)

Eye movements from a patient with left unilateral neglect, during visual exploration

Unilateral Neglect: Frames of Reference

"On the side opposite to": In what frame of reference does neglect occur (space, object, world)?

How do we define LEFT?

Reference Frame: system for representing locations relative to some standard coordinate system

Neglect affects multiple reference frames

Unilateral Neglect: Frames of Reference

Neglect patient JM's copying of a daisy presented in different orientions.

Spatial or object-centered?

Unilateral Neglect: Patient J.R.

Marshall and Halligan summarize J.R.'s deficit as follows:

"Conscious perception of the whole does not automatically lead to visual awareness of all the parts. […] J.R. can perceive the whole forest but cannot use that percept to search for and cut down the tress on the left thereof."

Unilateral Neglect: Summary

- *A unilateral attention deficit*
- *LH- strong right bias; RH- possible bilateral control (can direct left or right)*
- *Attention operates on representations, neglect can affect multiple representations*
- *Brain represents space in multiple frames of reference*
- *Posterior parietal cortex critical for attention*

Balint Syndrome

Main component: visual disorientation (simultanagnosia). Inability to attend to more than a very limited (and unstable) sector of the visual field (a single object) at any given moment (the rest is "out of focus"). Percept of a spatially coherent scene is lost.

Lesion: Most often, bilateral occipito-parietal lesions