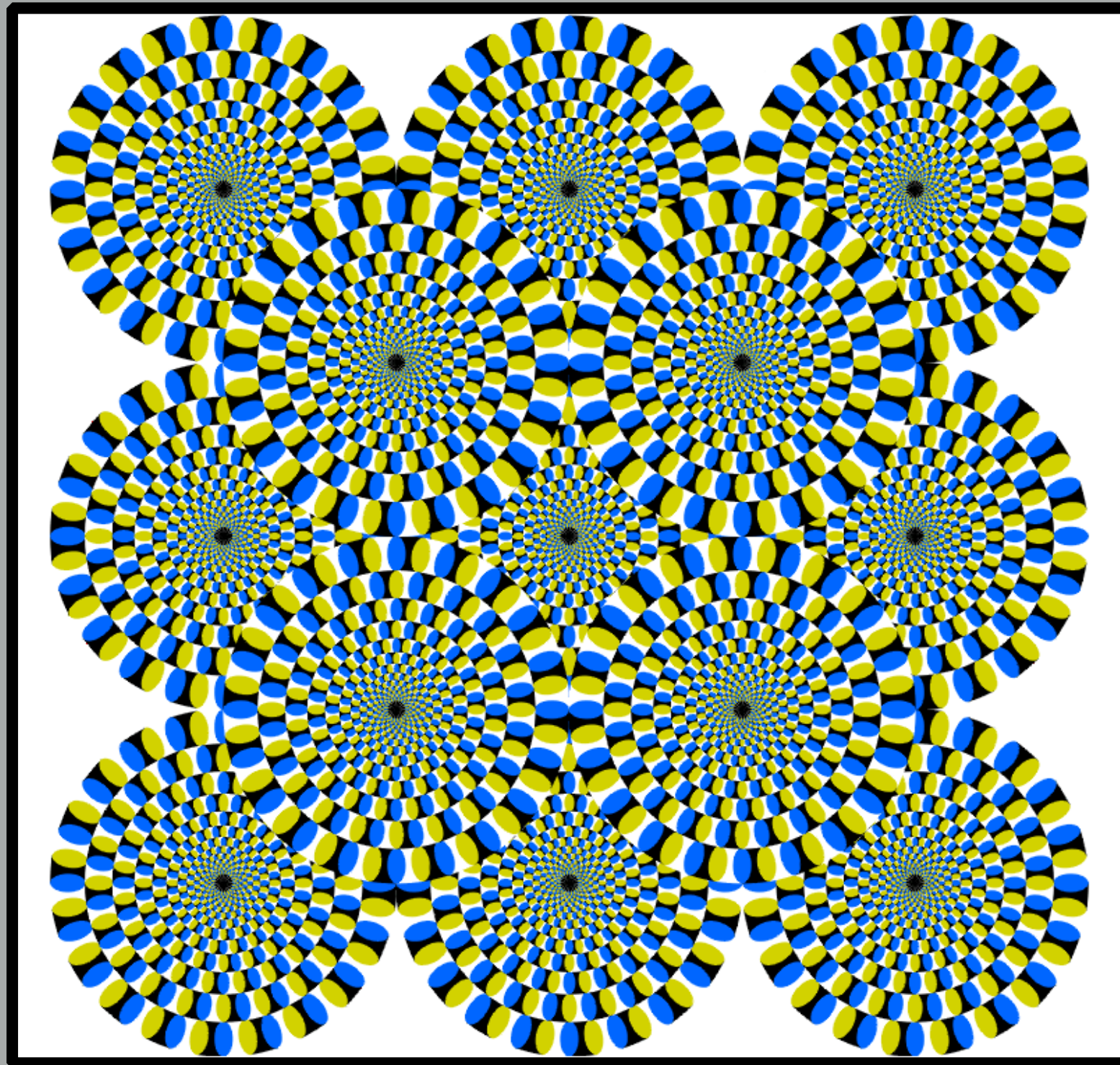


COGS500

Visual Attention



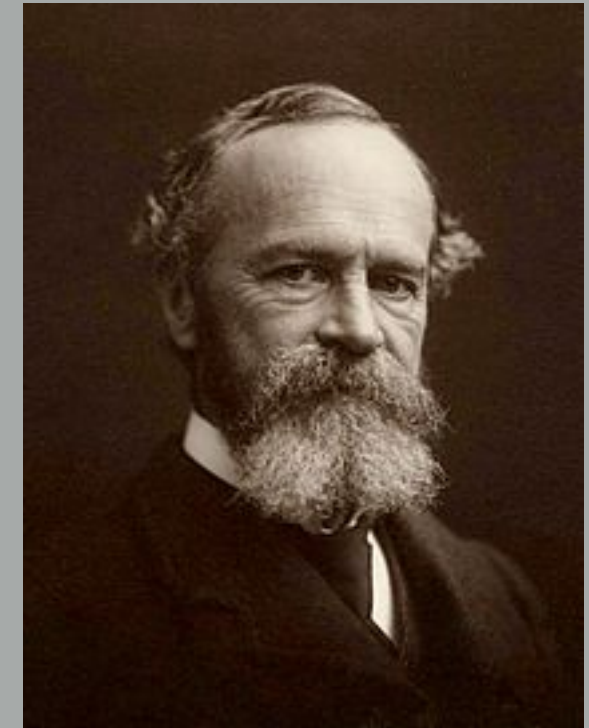
Boun, Dec 2018
İ. Ayhan

What is 'Attention'?

In the old days:

William James (1890): "Everyone knows what attention is..."

Munsell (1873): "On attention itself it is needless to discourse at length; it's nature and conditions are familiar to every thoughtful student."



William James



Harold Pashler, UCSD

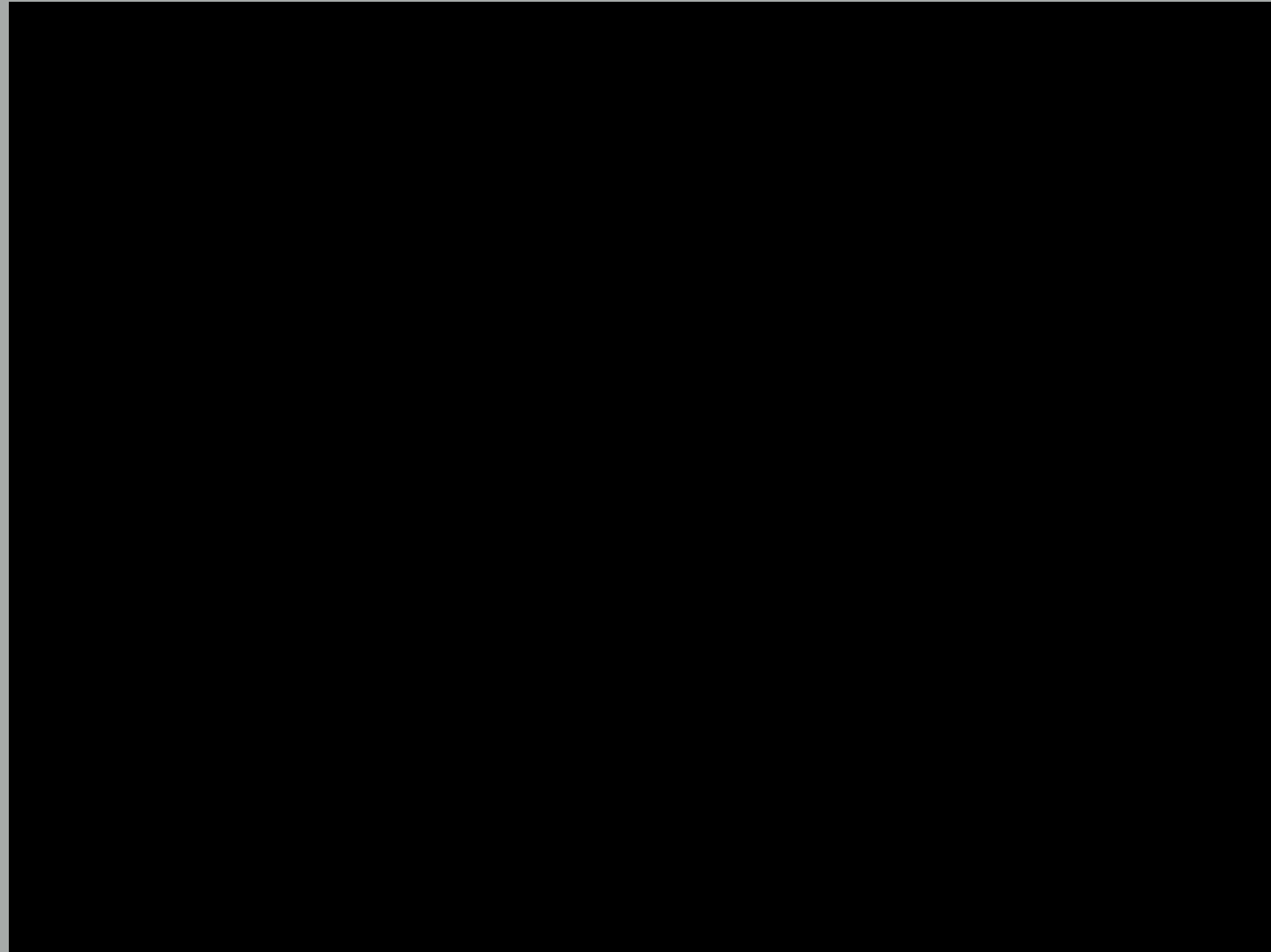
Nowadays:

Pashler (1998):

"No one knows what attention is, and there may not be an it there to be known about (although of course there might be)."

Instead of attempting to define attention we study the effects it has on cognitive functions

Attention Induced Blindness



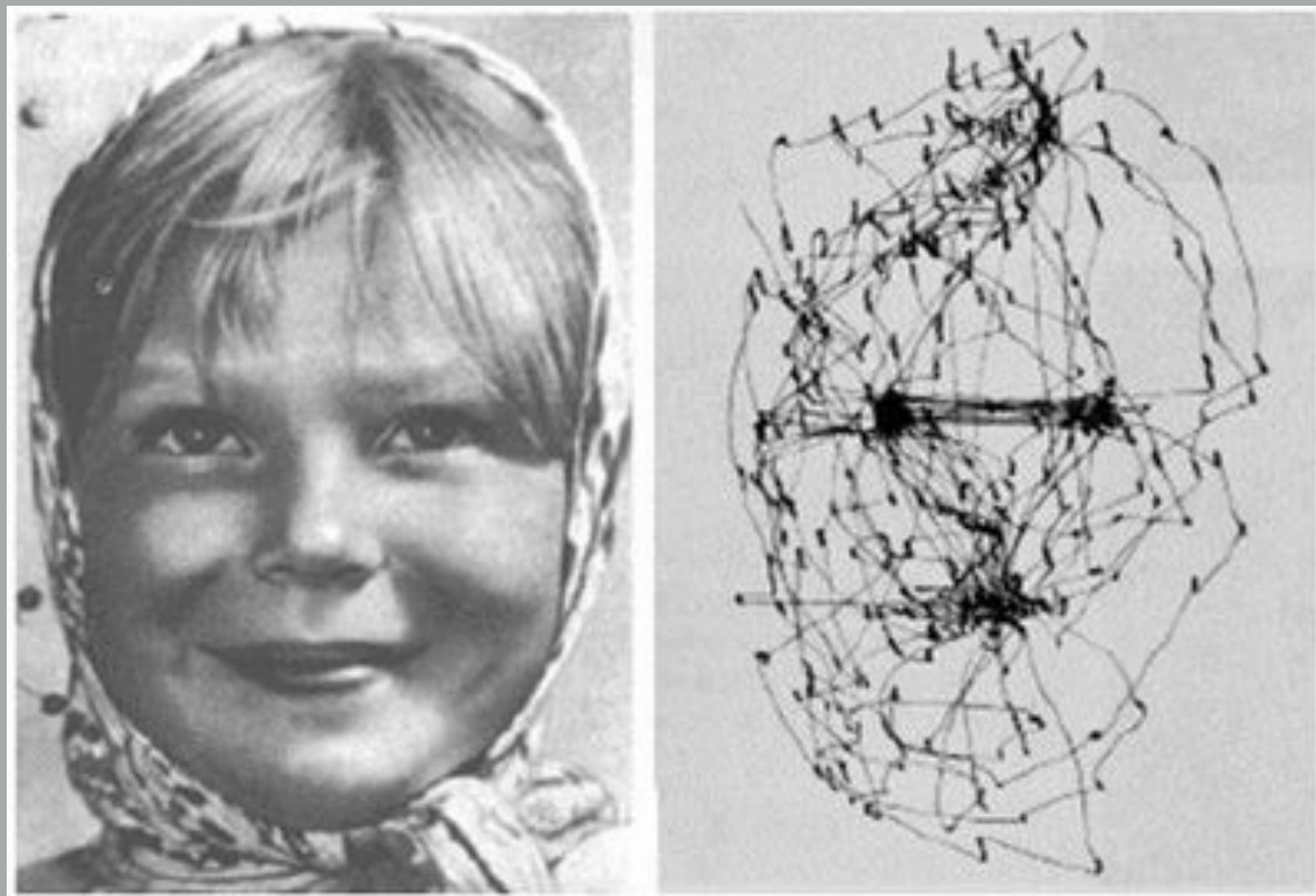
The effects of attention on cognitive functions
(e.g. perception, memory)

The role of attention in facilitating perception
and any further processing (e.g. action,
memory) for relevant stimuli

The role of attention in preventing perception
and any further processing (e.g. action,
memory) for irrelevant stimuli.

Attention and Eye Movements

- Saccades: quick eye movements from one fixation location to another.
- We make around 3 saccades per second!



Not all parts of a scene are sampled equally

Early eye tracking: 1920-30's. Developed fastly through 1970's.

What determines where we look?

Bottom up factors: Characteristics of the scene:

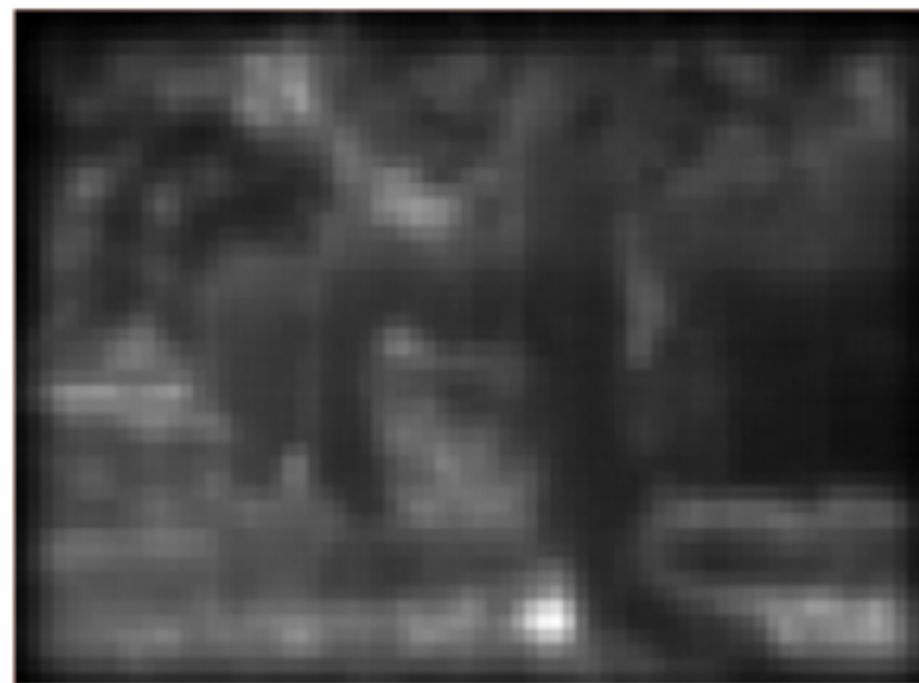
Stimulus salience - areas of stimuli that attract attention due to their properties:

- Color, contrast, and orientation are relevant properties
- Saliency maps show fixations are related to such properties in the initial scanning process

Visual Image



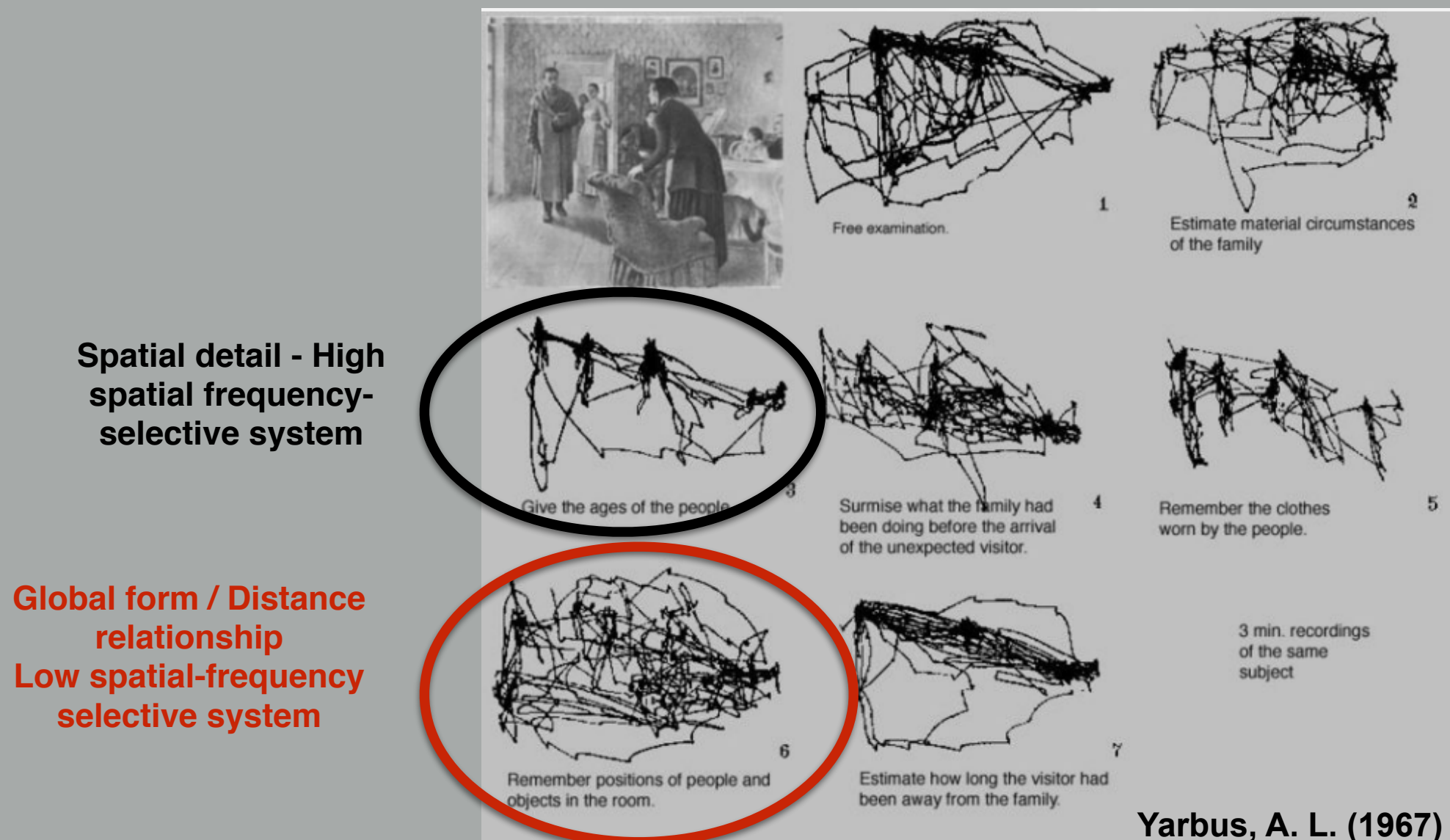
Saliency Map



What determines where we look?

Top down factors:

- Task or goals
- Attention
 - Where to attend (spatial attention)
 - What features to attend to (feature-based attention)

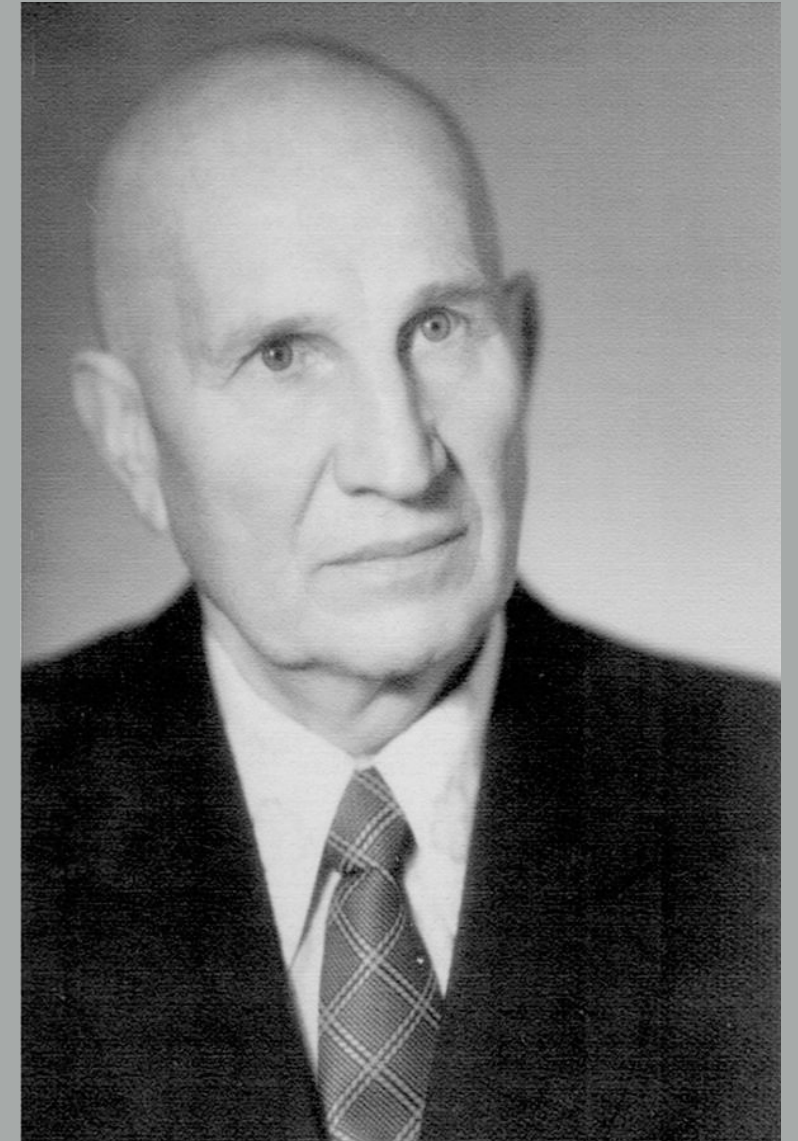
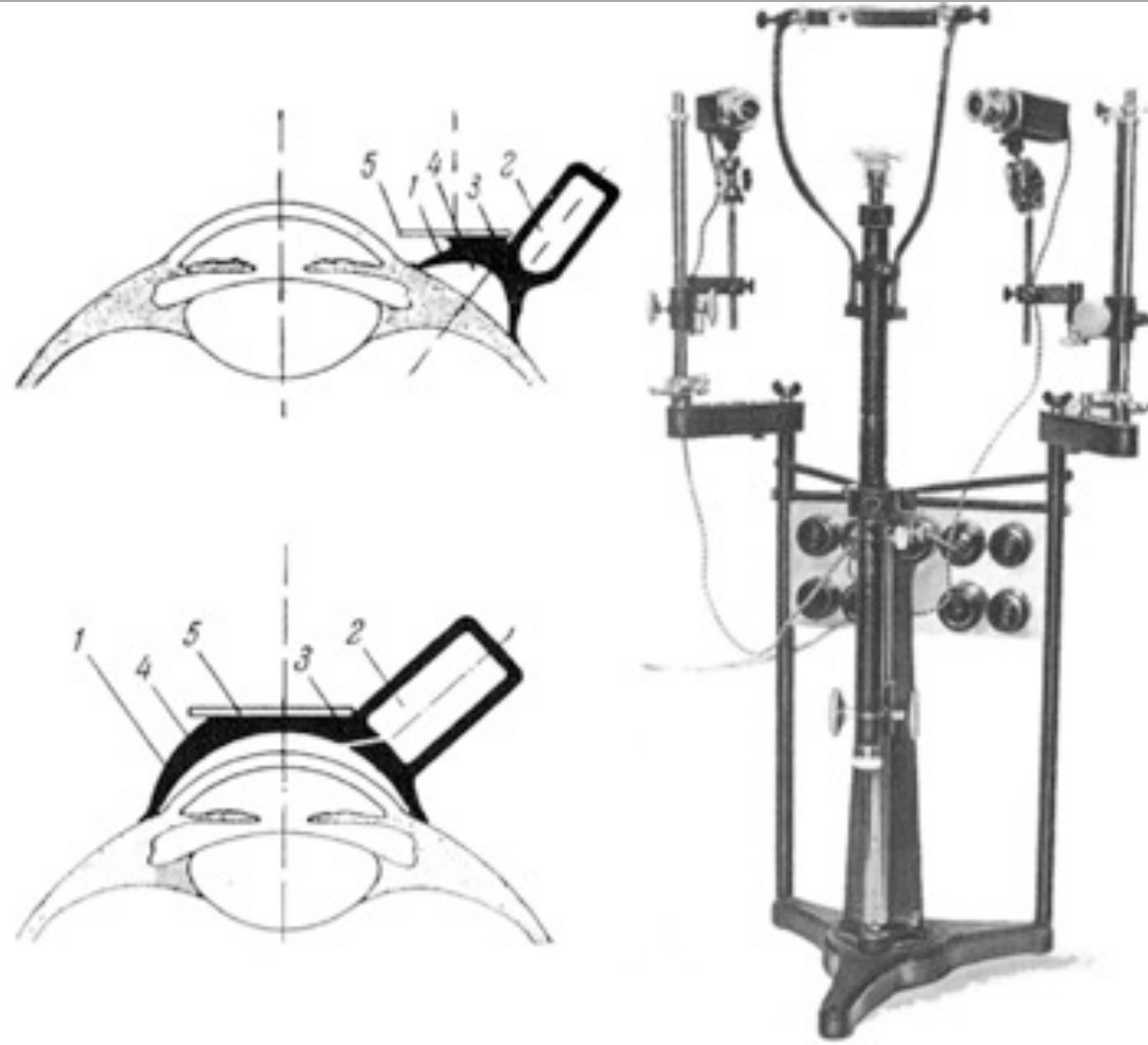
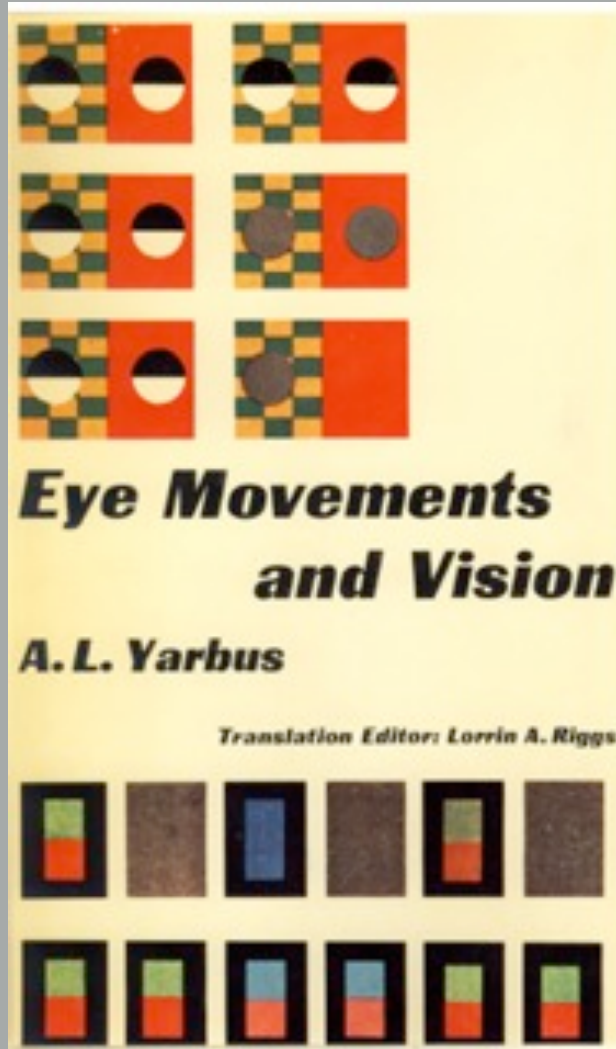


The gaze tends to jump back and forth between the same parts of the scene, for example, the eyes and mouth in the picture of a face.

The task has a strong influence on where you attend and look

What determines where we look?

Alfred Yarbus was a Russian psychologist who studied eye movements in the 1950s and 1960s



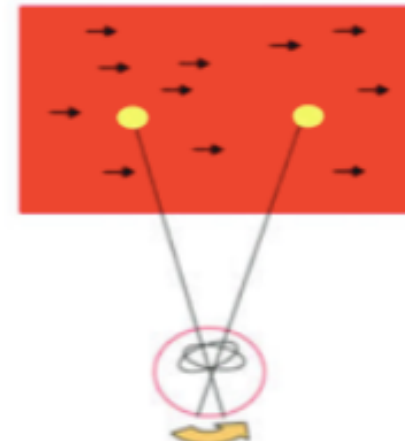
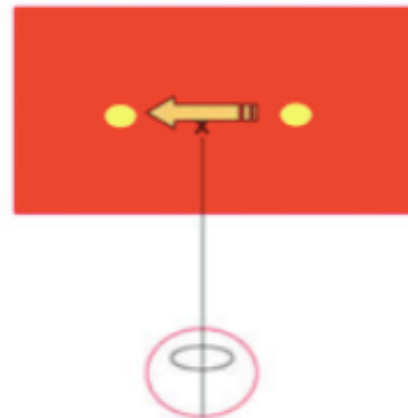
Science in Soviet Russia

Yarbus also invented a suction cup, which can be attached by suction to the human eye to study visual perceptions in the absence of eye movements, a laboratory condition called retinal stabilization

~ Eye Movements ~

Motion can be sensed in two ways:

1. *retinal movement system*
2. *eye / head movement system*

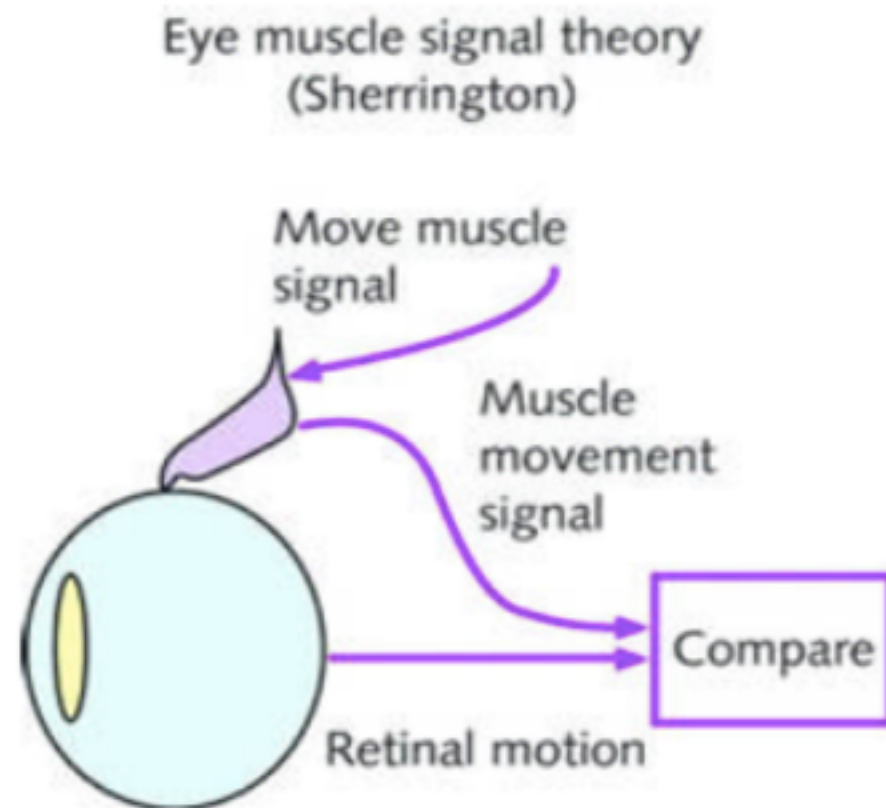


The viewer fixates on a stationary object therefore moves across retina.

Observer tracks the moving object >> moving object remains stationary on retina >> stationary background moves on the opposite side

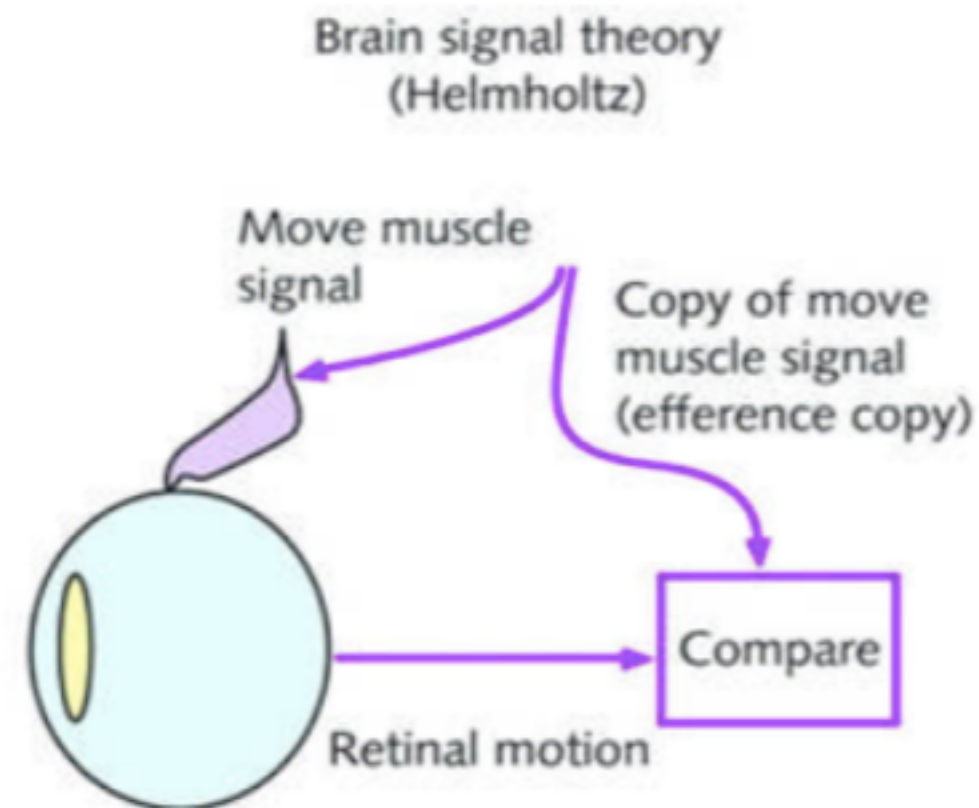
Tracking - smooth pursuit eye movements

Sherrington's Theory



We monitor the movements of our eye muscles and compare **retinal image motion** to **eye muscle movement**.

Helmholtz' Theory



The comparison is made with **the signal from the brain** that tells the eye muscle to move (**efferent copy** or **corollary discharge**) and the retinal image motion.

 Sherrington's Theory

Helmholtz' Theory



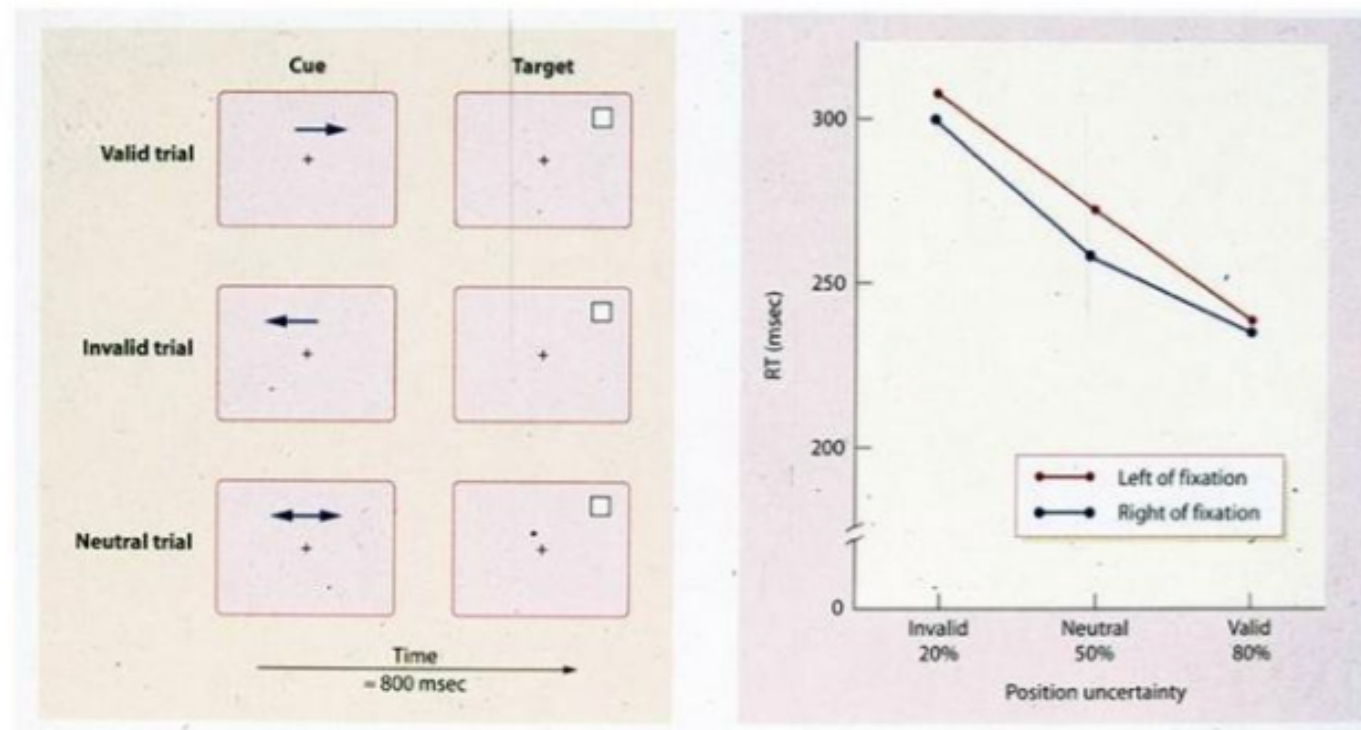
What if we tell our eyes to move but we actually prevent the eyeball from moving?

Helmholtz predicts that the stationary world will appear to move because the eye movement signal is not cancelled by the expected retinal movement. Sherrington predicts no movement because there will be no retinal movement and no eye muscle movement.

the experiment has been done: the world does move (**Stevens et al., 1976**)

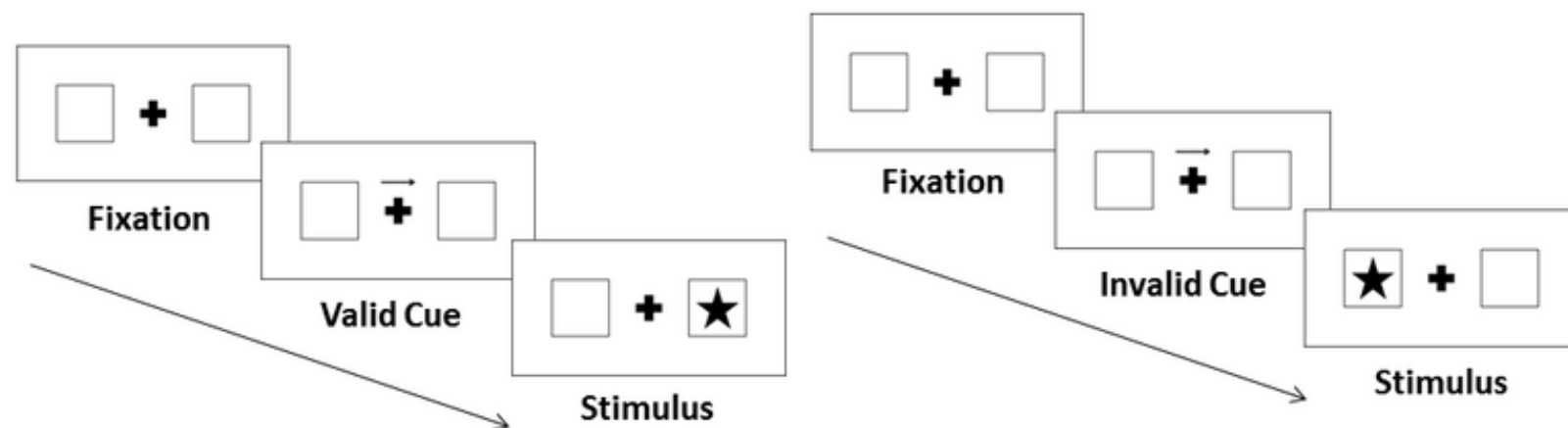
- **Spatial Attention**
- We use spatial attention to highlight everything at a particular location

Covert Attention: a difficult (threshold) visual discrimination task.

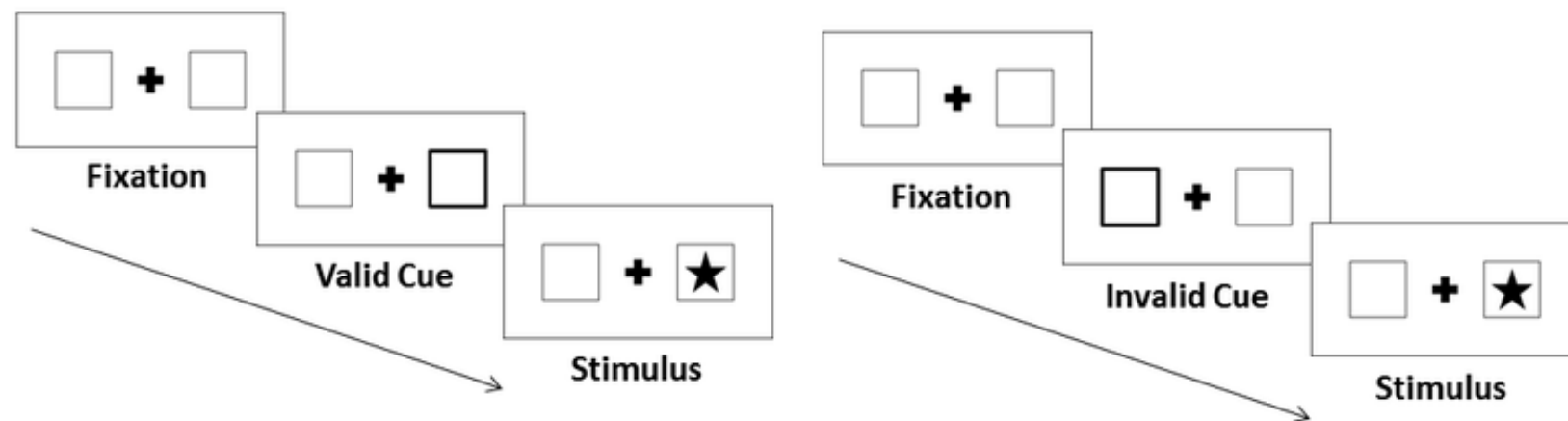


- You can shift spatial attention without eye movements.
- The shifts can be controlled by the subject's decision to allocate attention (e.g., with instructions, or with a central arrow as a cue) or by automatic attraction (e.g., if something suddenly appears in the periphery of your visual field).
- Performance falls off smoothly with distance when cued to the wrong location.

Endogenous Cues



Exogenous Cues



- An endogenous cue is presented in the center of the screen, usually at the same location as the center of focus. This cue relies on input from the central visual field.
- An exogenous cue is presented outside of the center of focus, usually highlighting the left or right box presented on the screen (peripheral input).

- ***Spatial Attention***

- Types of covert spatial attention: Endogenous and Exogenous

- Sustained (endogenous)

voluntary, or by instruction in laboratory experiments: “attend left”.

- willfully monitor information at a given location. Goal oriented.
- 300 ms,
- Affects performance only under high noise conditions.
- Feedback from frontal and parietal areas.

- transient (exogenous)

involuntary, often by a flash, sound or any sudden change.

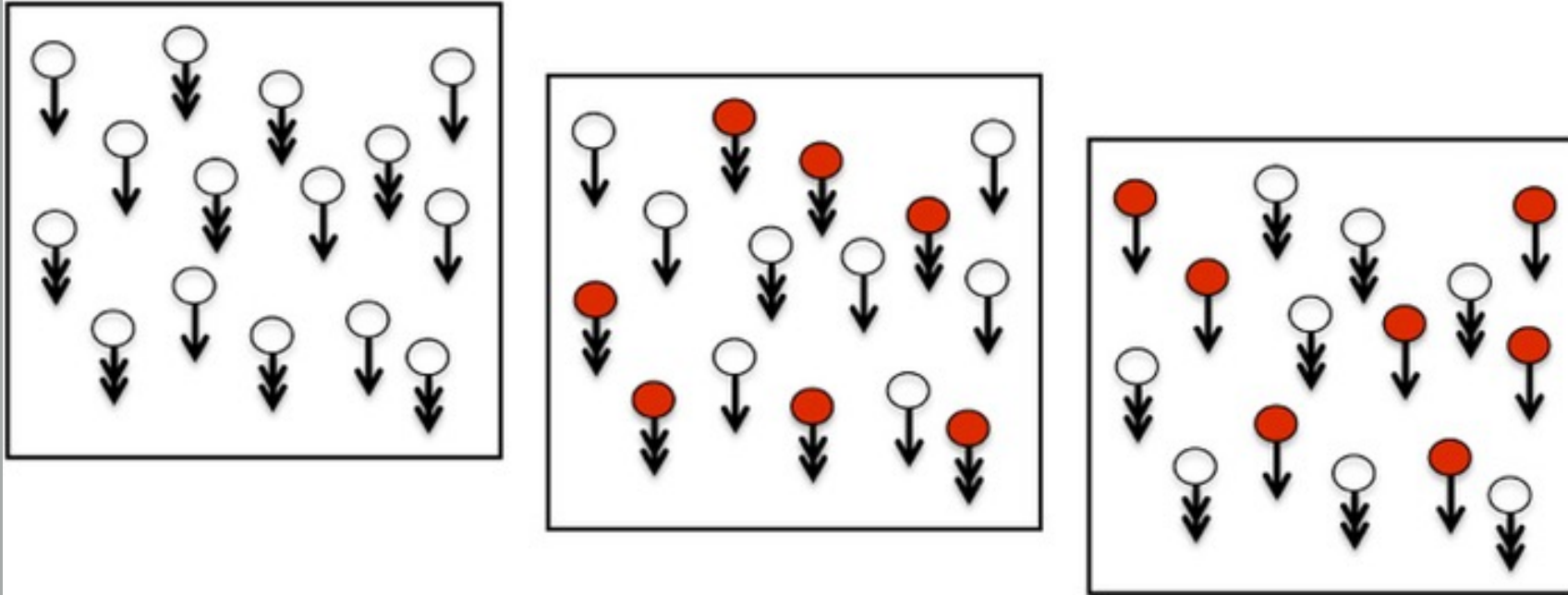
- automatic orienting response to allocation where sudden stimulation has occurred.
- It rises and decays quickly peaking about 100-120 ms. Faster time course.
- allowing us to respond to environmental demands and react quickly to stimuli
- Older in evolution.
- Can operate under both low and high noise conditions.

Saliency

- ***Feature-Based Attention***

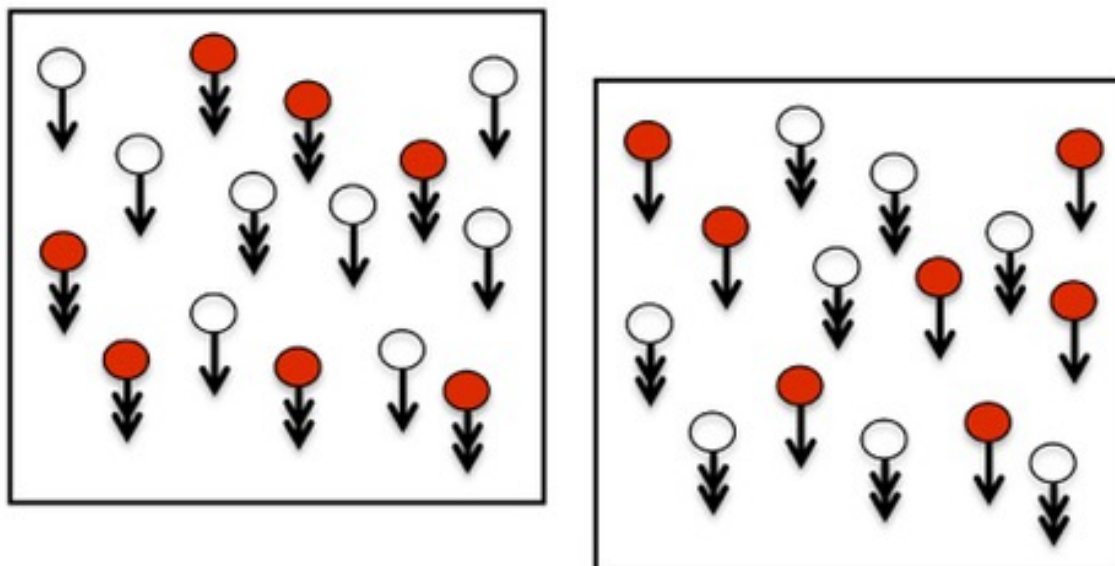
- We use feature-based attention to highlight specific features throughout a scene.

a Experiment 1: attend fast or slow moving surface



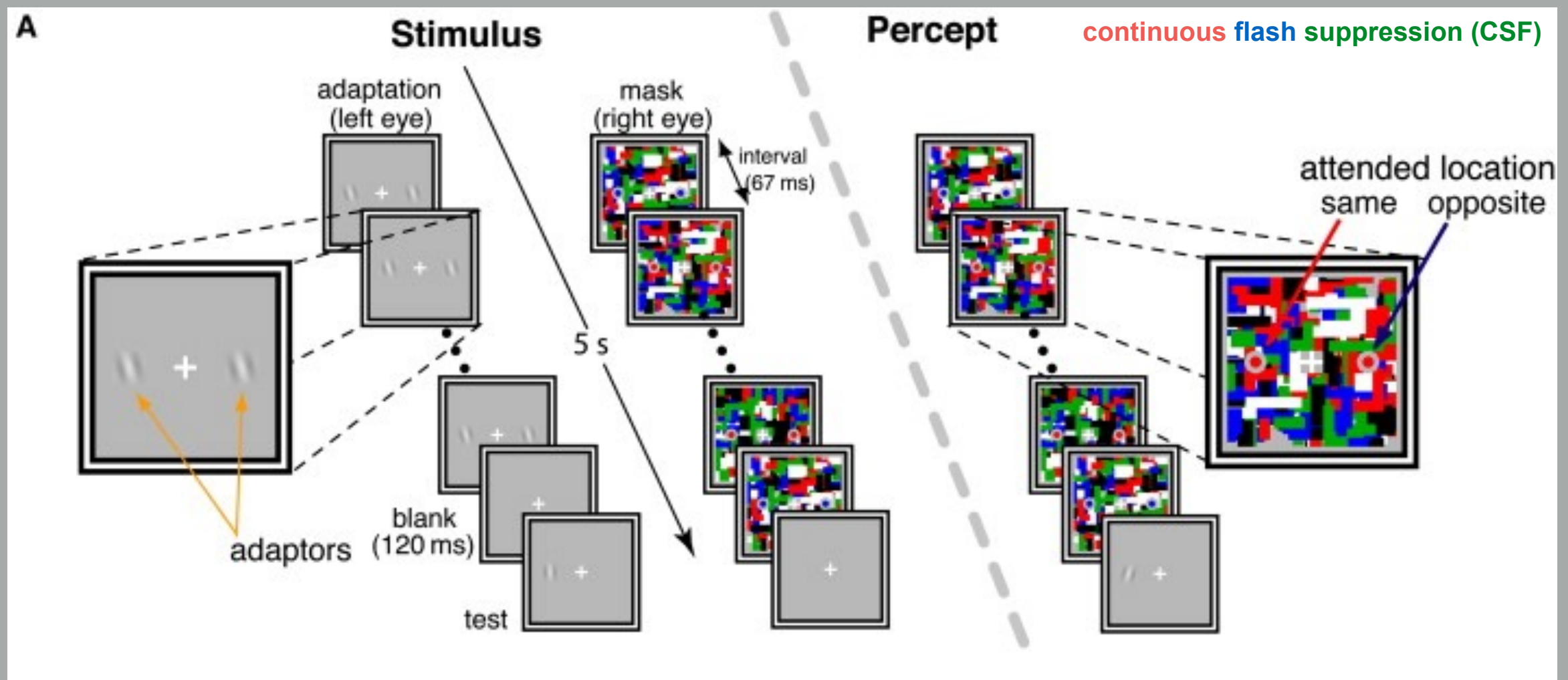
- i.e. speed or colour

c Experiment 2: attend red or gray surface

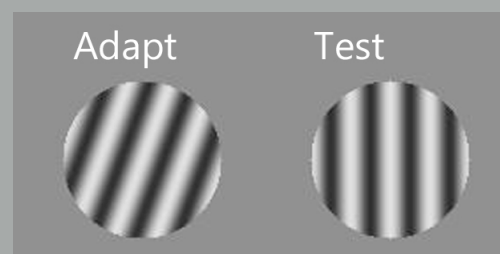


- ***The Dissociation Between Visual Attention and Awareness***

Kanai, R., Tsuchiya, N. & Verstraten, F. (2006). The scope and limits of top-down attention in unconscious visual processing.
Current Biology, 16 (23), pp 2332–2336.

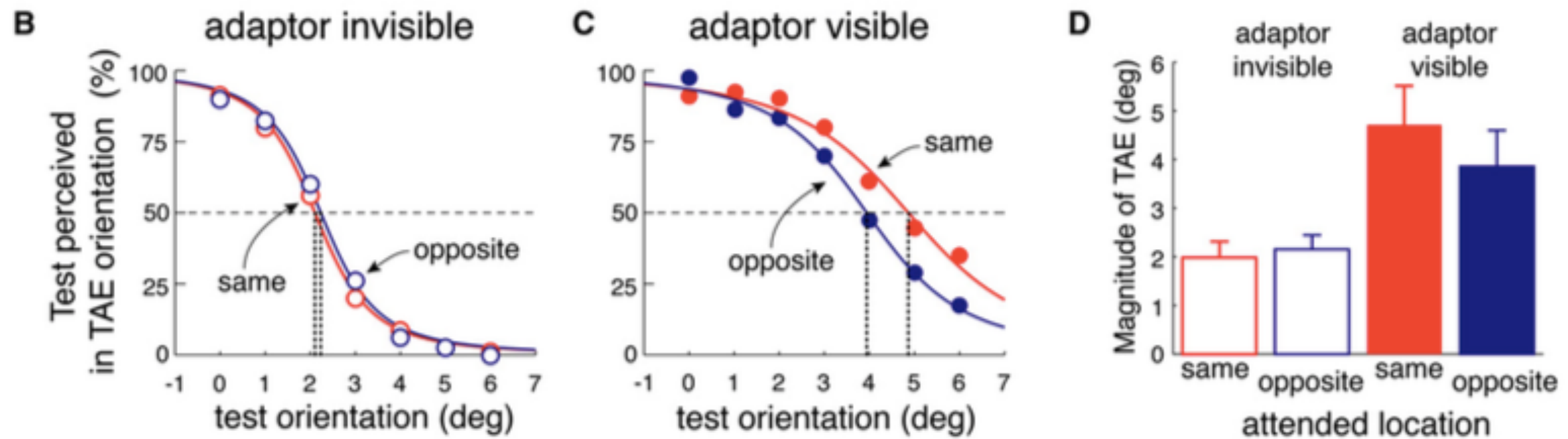


C



Tilt aftereffect

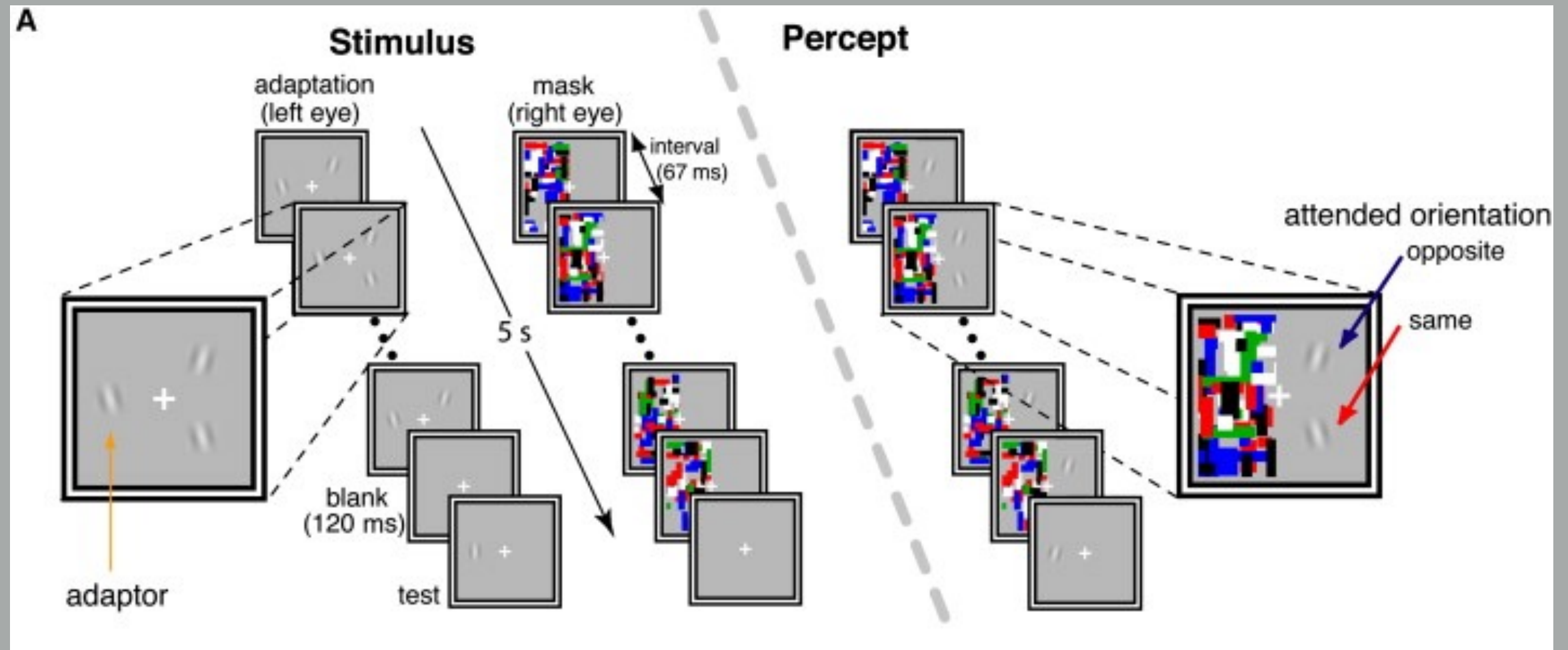
Kanai, R., Tsuchiya, N. & Verstraten, F. (2006). The scope and limits of top-down attention in unconscious visual processing.
Current Biology, 16 (23), pp 2332–2336.



Positive values indicate a slight tilt to rightwards direction after having adapted to rightwards tilt

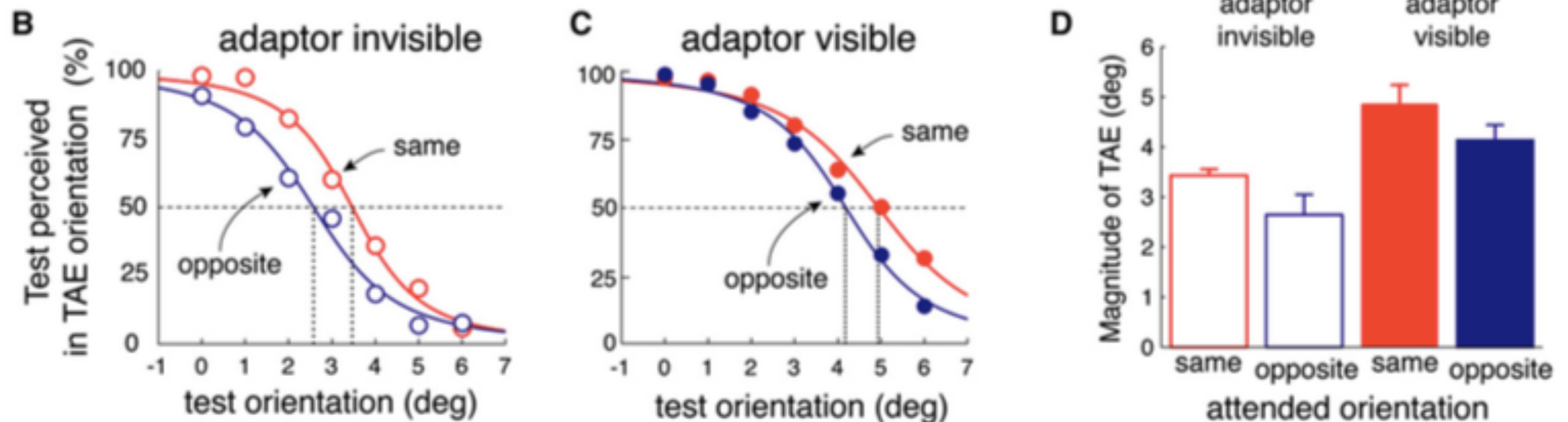
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feature-based attention can modulate the processing of invisible stimuli.

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Koch, K. & Tsuchiya, N. (2006). Attention and consciousness: two distinct brain processes. *Trends in Cognitive Sciences*, 11 (1), pp 16 – 22



Opinion

TRENDS in Cognitive Sciences Vol.11 No.1

Full text provided by www.sciencedirect.com


Attention and consciousness: two distinct brain processes

Christof Koch¹ and Naotsugu Tsuchiya²

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Table 1. A fourfold classification of conscious and unconscious percepts and behaviors^a

	Might not give rise to consciousness	Gives rise to consciousness
Top-down attention is not required	Formation of afterimages Rapid vision (<120 ms) Zombie behaviors	Pop-out in search Iconic memory Gist Animal and gender detection in dual tasks Partial reportability
Top-down attention is required	Priming Adaptation Visual search Thoughts	Working memory Detection and discrimination of unexpected and unfamiliar stimuli Full reportability

- *Zombie Behaviours*

Action without Awareness

Blindsight: brain damage to V1 in one hemisphere leaves the subjects totally blind (no visual awareness) in large parts of the contralateral visual hemifield.

Blindsight was first described in patients with gunshot wounds to the striate cortex, who move their eyes towards or point at small visual stimuli which they claimed they were unable to “see”

non-visual awareness of a visual stimulus has been described by subject GY as "The nearest I ever get, and it is not a fair comparison, is waving your hand in front of your eyes when they are closed. You are kind of aware that something happened but you don't quite see it."

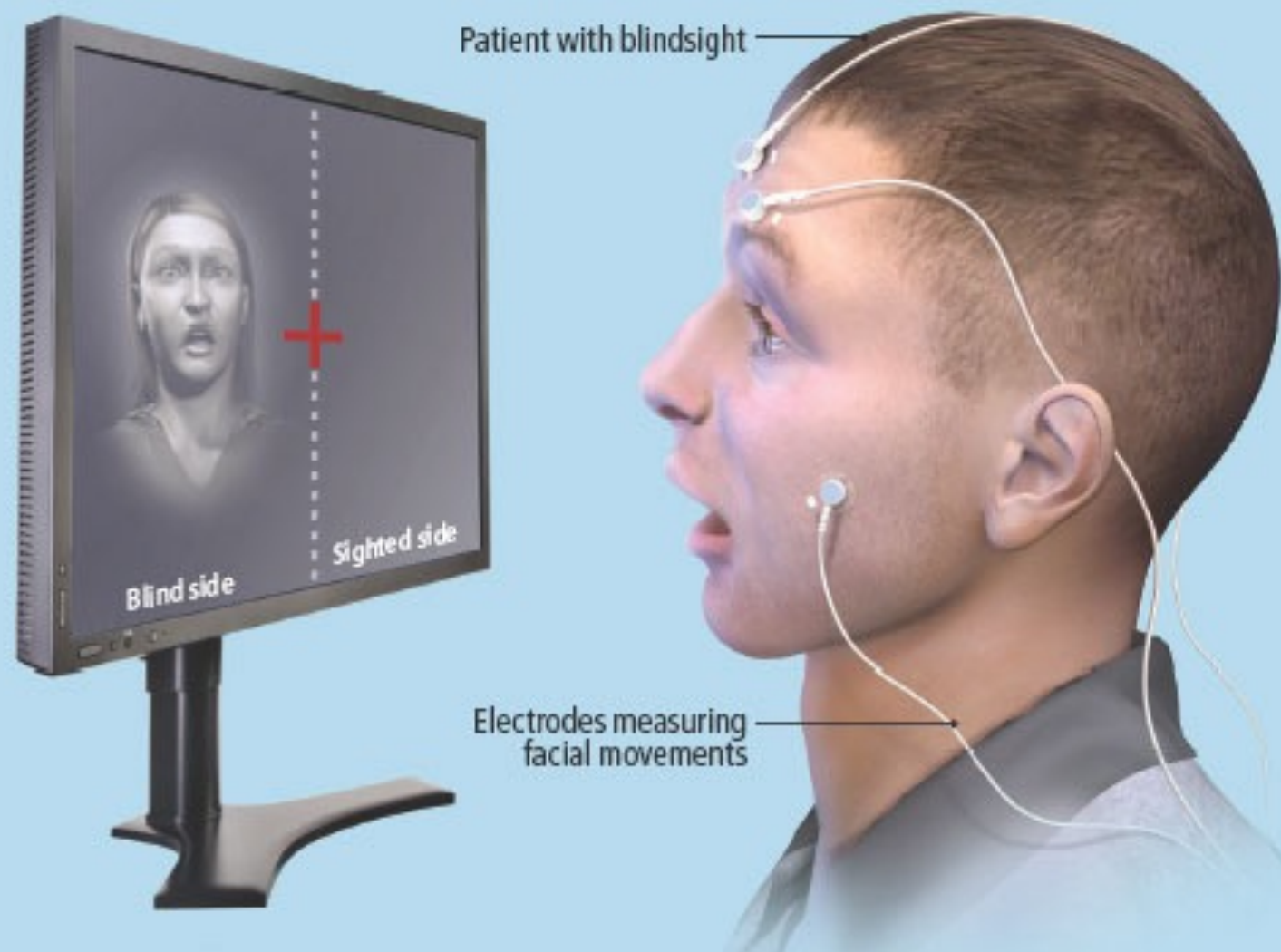
[EXPERIMENTS]

Investigating Blindsight

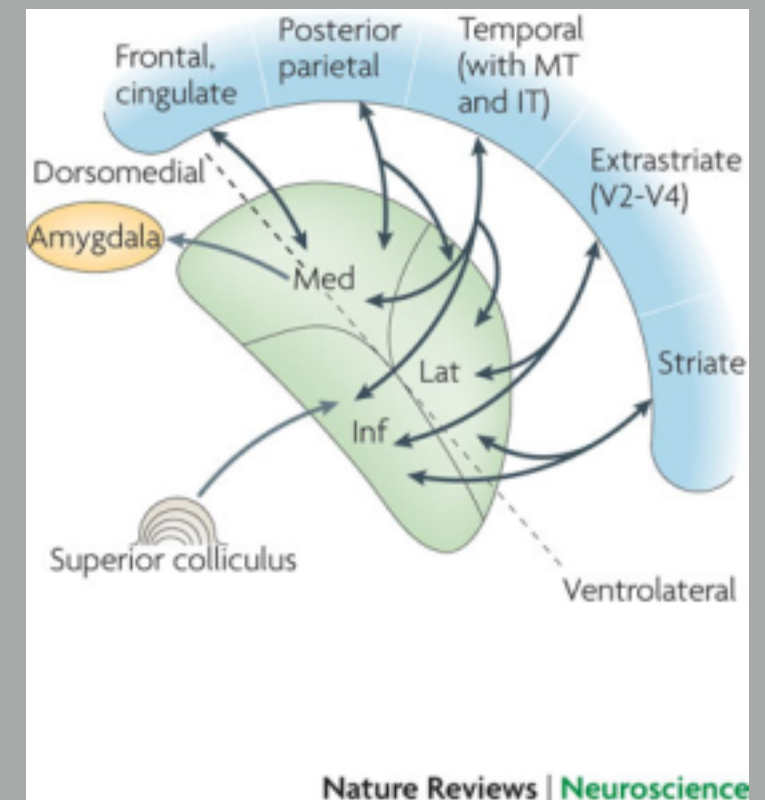
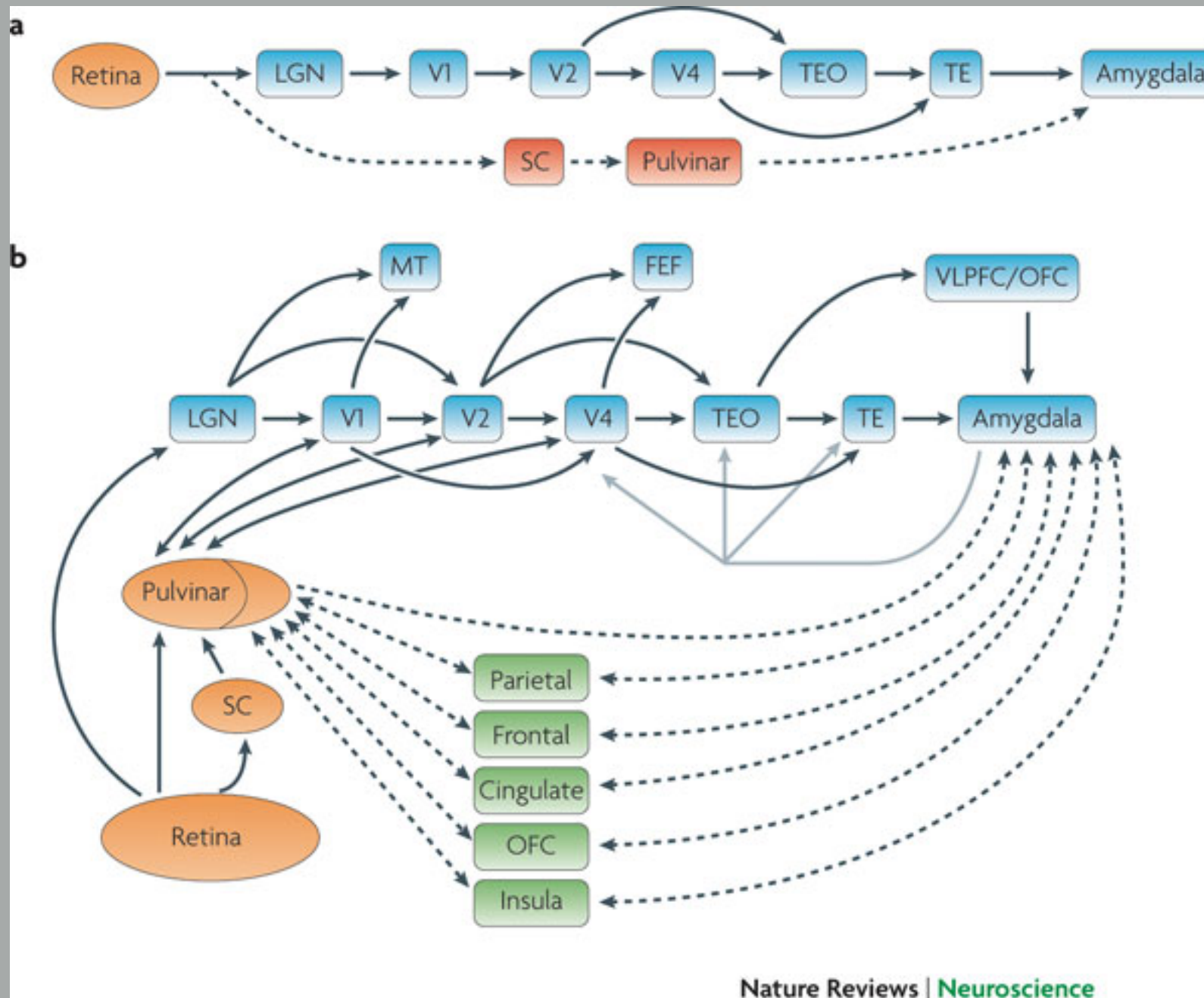
Because total cortical blindness like patient TN's is rare, studies of blindsight often use patients blind on one side of their visual field. The patient stares at a fixed point while images are presented on each side. The subject may be asked to "guess" what is on the blind side or to press a button on seeing items on the sighted side. Equipment may monitor brain activity and measure involuntary responses such as tiny facial movements and pupil dilation.

▼ DOES BLINDSIGHT SEE EMOTIONS?

Patients shown images on their blind side of people expressing emotions correctly guessed the emotion most of the time. Facial muscles used in smiling and frowning reacted in ways that matched the kind of emotion in the unseen image (*below, exaggerated*). Thus, the emotions were recognized without involving conscious sight. The effect worked with images of faceless bodies as well as faces, implying that patients were recognizing an emotion and not merely mimicking a facial expression unconsciously.



Without V1, how did these signals get to the dorsal pathway?
 There's a second pathway to the dorsal stream that bypasses V1!
Retina – Superior Colliculus - Pulvinar



The pulvinar works in a way that integrates cortical-subcortical processing.

Behavioral studies have shown that the SC is not needed for object recognition, but plays a critical role in the ability to direct behaviors toward specific objects >> *gaze shifts*

Lesions of the pulvinar can result in neglect syndromes and attentional deficits

- ***Change Blindness***

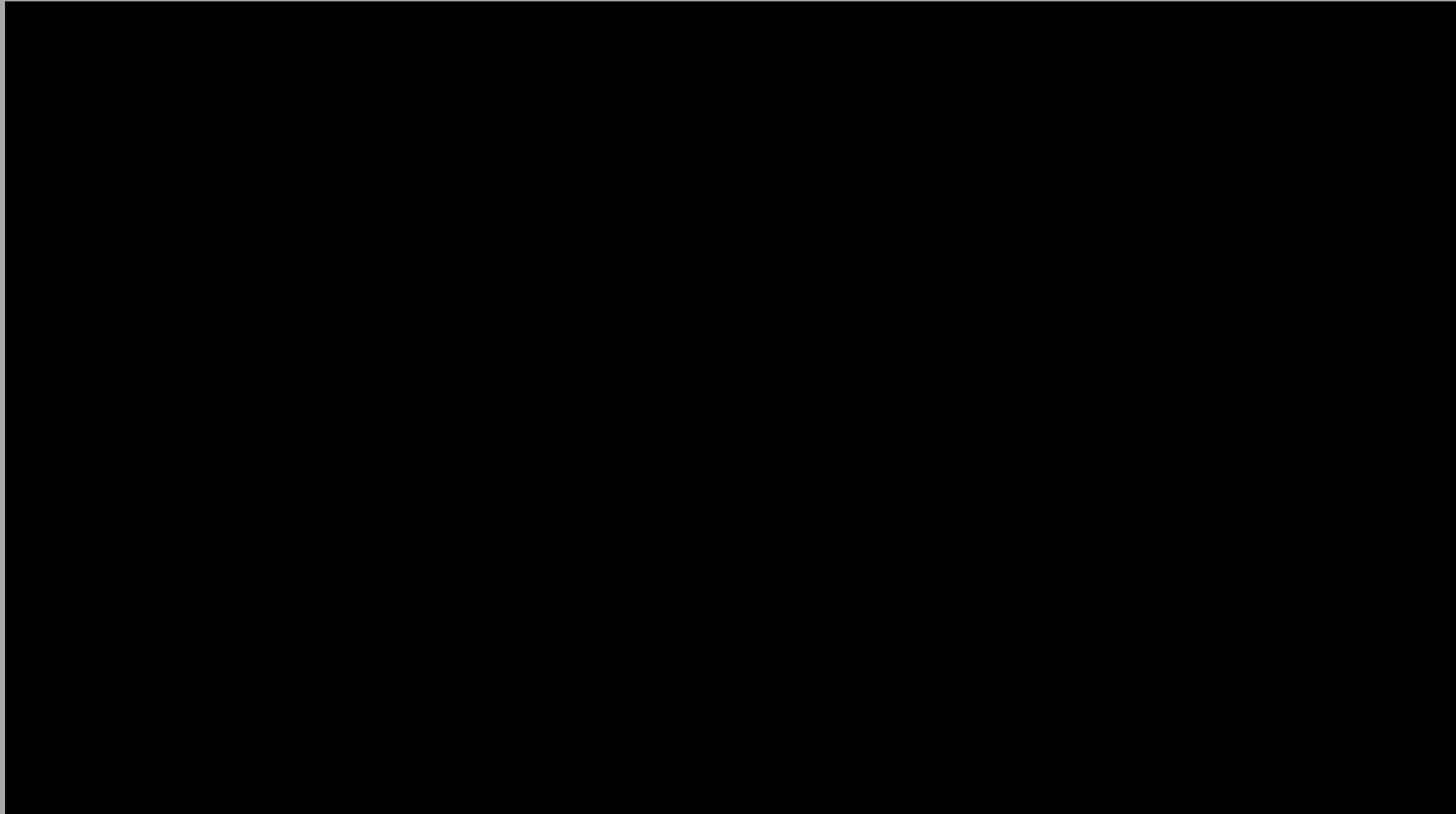
- Attention, eye movements, and memory allow you to ‘paint’ a coherent scene in your mind.

BUT

with an assumption that the outer world remains stable.

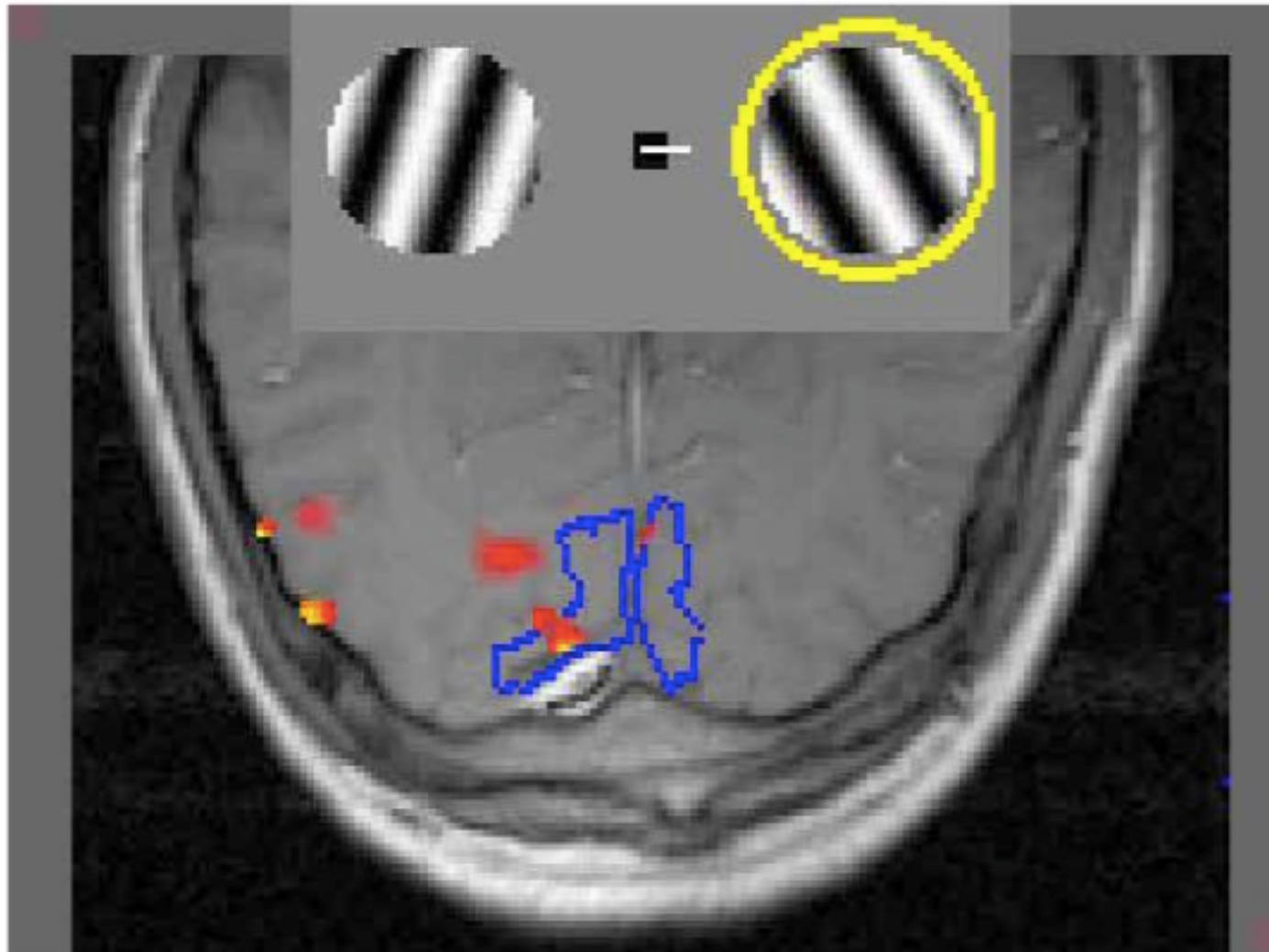


- ***Flicker Induced Change Blindness***
- Observers are shown a picture with and without a missing element in an alternating fashion with a blank screen
- Results show that the pictures had to alternate a number of times before the change was detected



Attentional Modulation of V1 Brain Activity

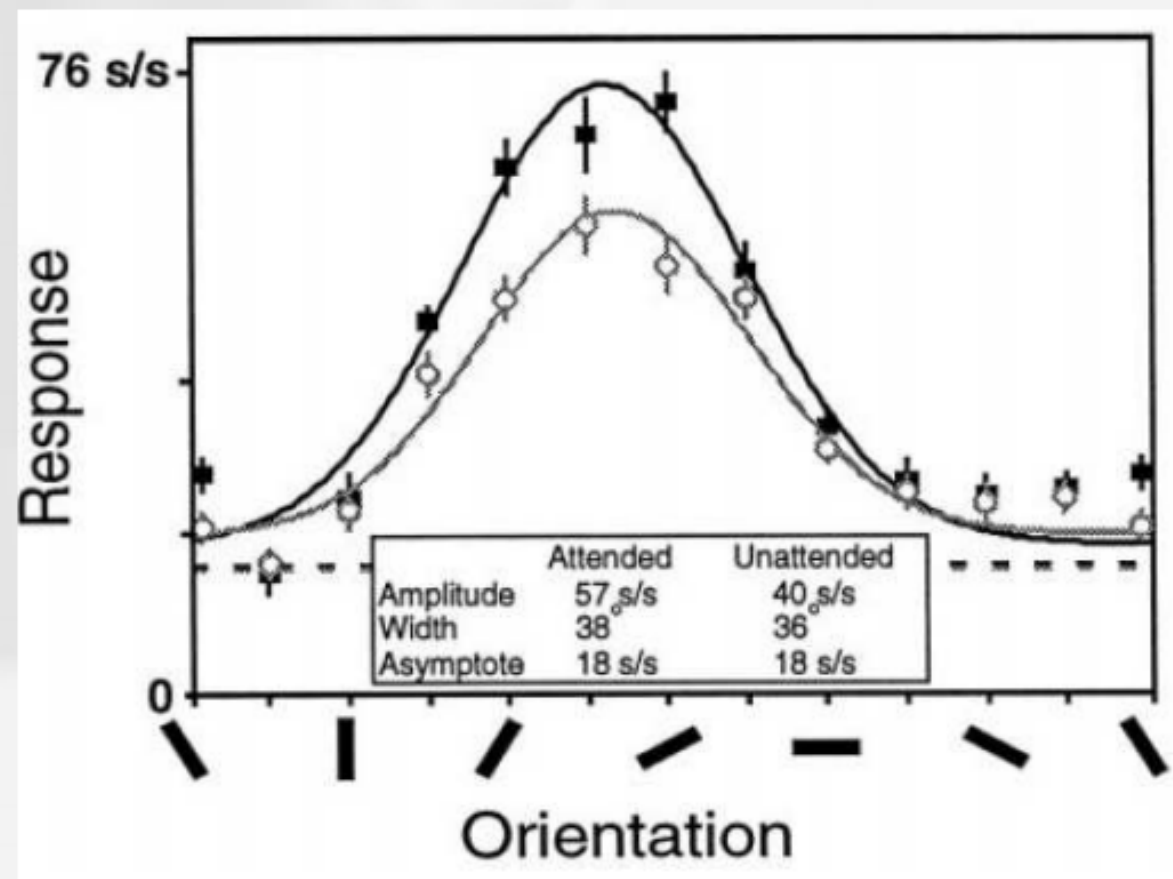
<http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/attention/attention.html>



fMRI responses in V1 are increased by spatial attention

How does **spatial attention** affect neuronal responses in the visual cortex?

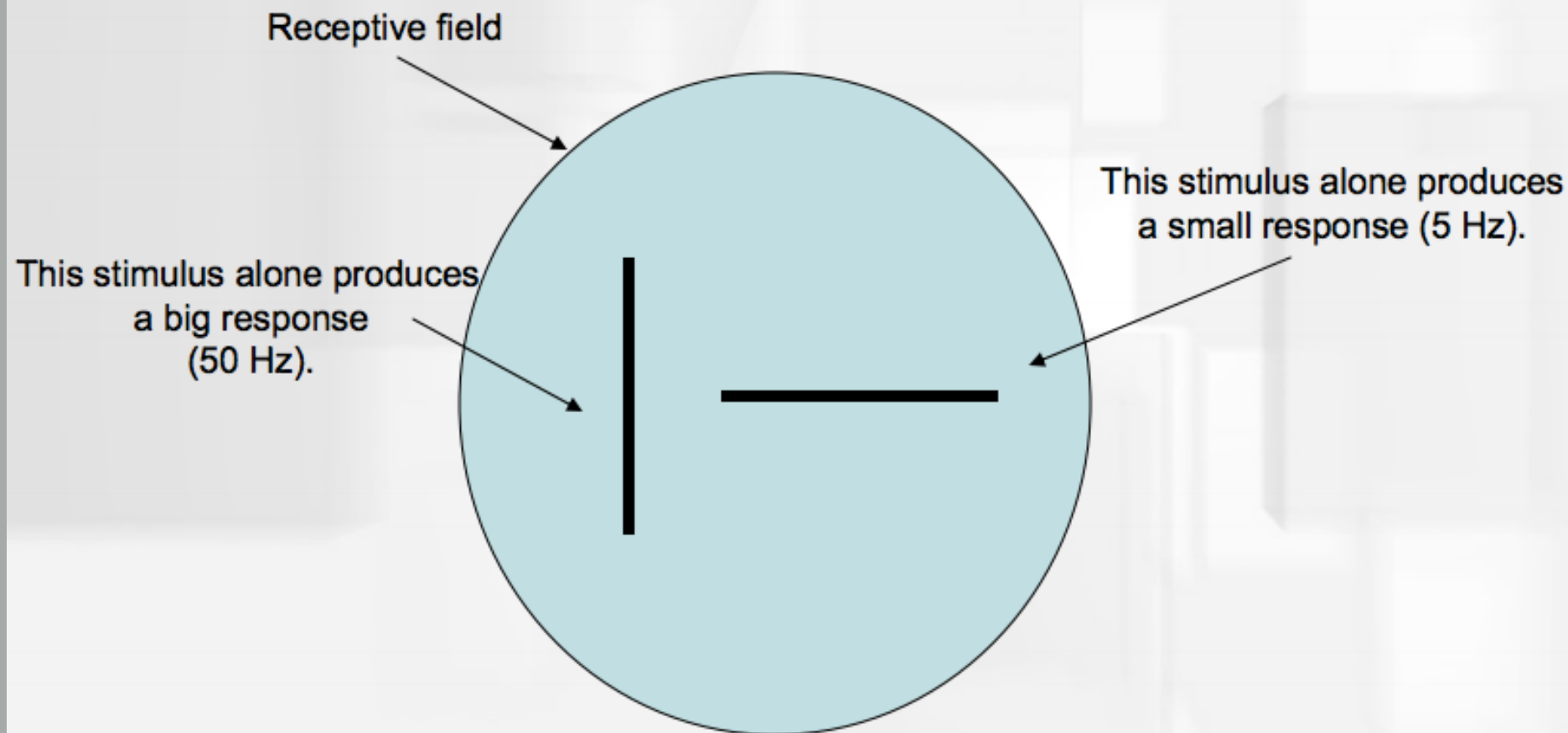
Electrophysiological experiment: have monkeys attend or ignore a stimulus in the receptive field of a neuron.



Electrophysiological responses (spikes) increase with spatial attention in macaque V1 (and area V4) without changing the shape of the orientation tuning

How does **feature-based attention** affect neuronal responses in the visual cortex?

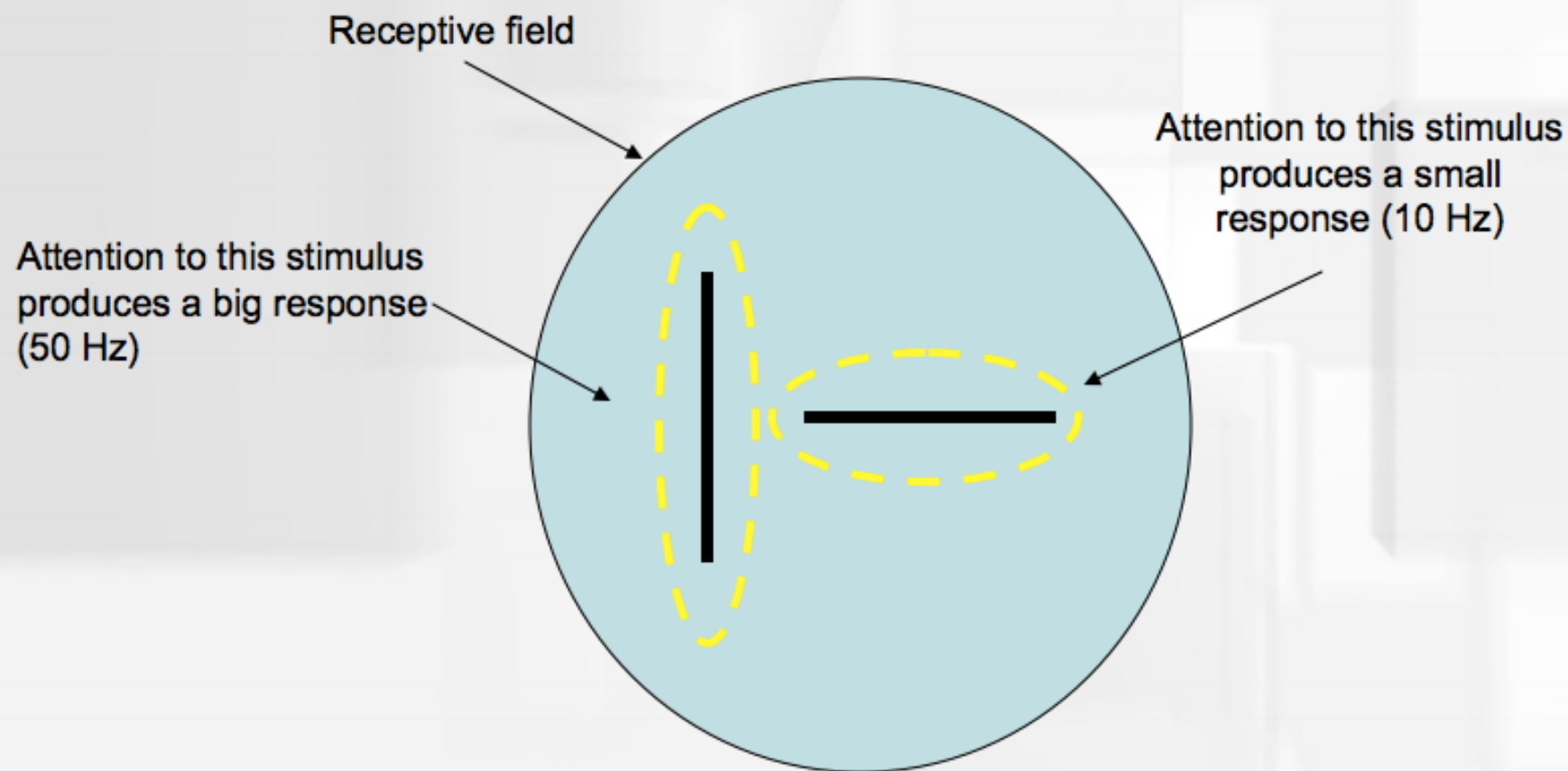
Electrophysiological experiment: present two stimuli in the receptive field of a V4 neuron



Presented together, the stimuli produce an intermediate response (20 Hz).

How does **feature-based attention** affect neuronal responses in the visual cortex?

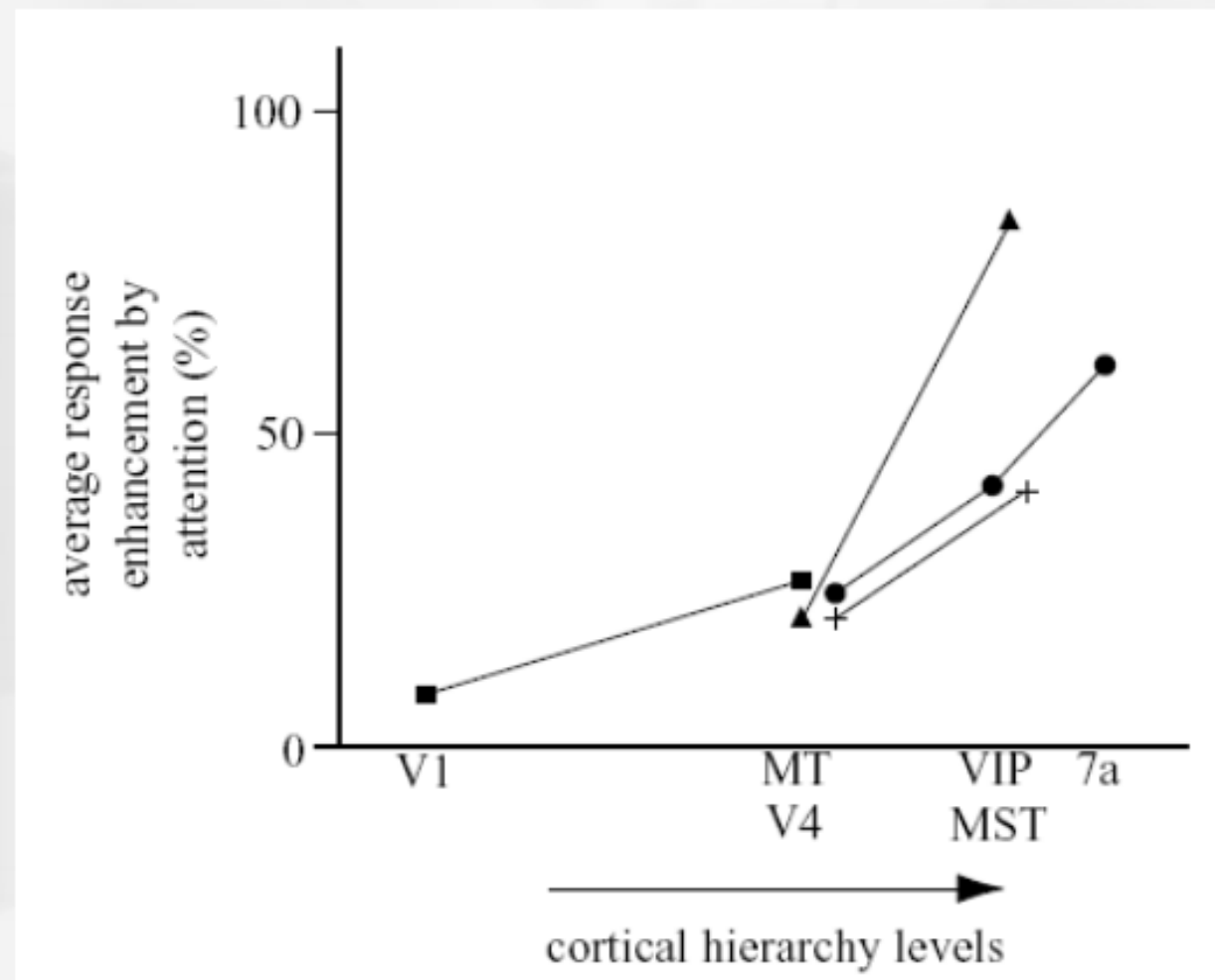
Electrophysiological experiment: now have monkeys attend to one of the two stimuli.



Applying feature-based attention (to orientation) is like removing the unattended stimulus from the receptive field.

Moran and Desimone, 1995

Effects of attention increase along the hierarchy of visual areas

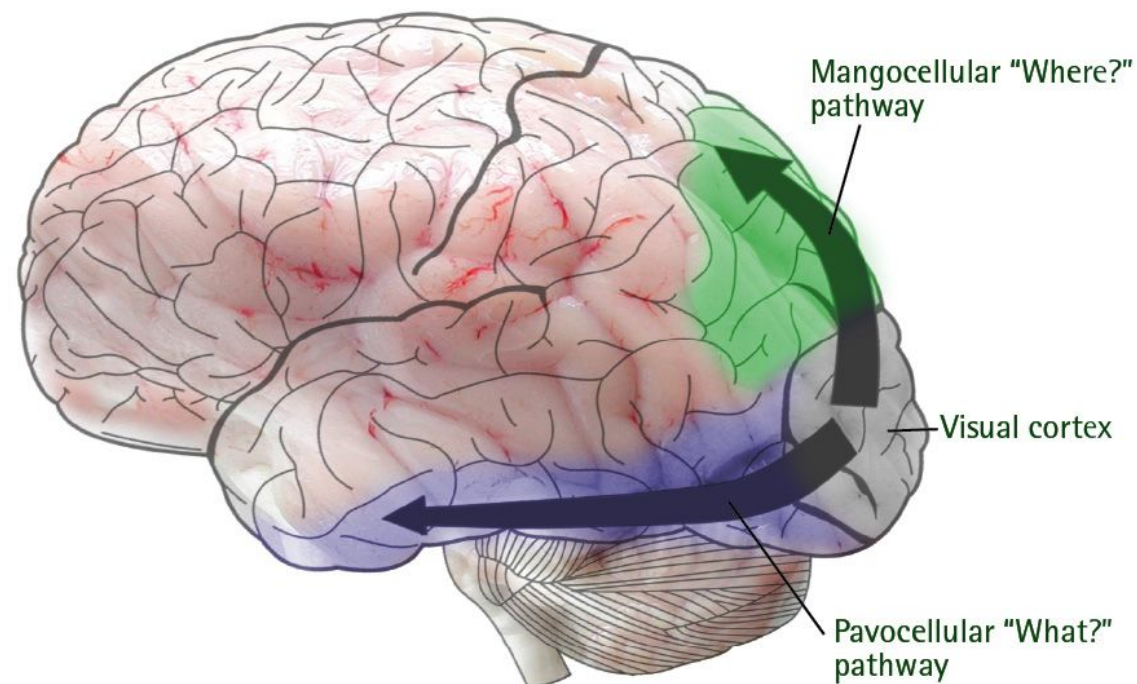


General rule:

Responses in early visual (LGN, V1) areas depend on the visual stimulus.
Responses in higher areas (V4, MT, Parietal) reflect what you actually experience.

Temporal Attention

What are the mechanisms register time at the neuronal level?

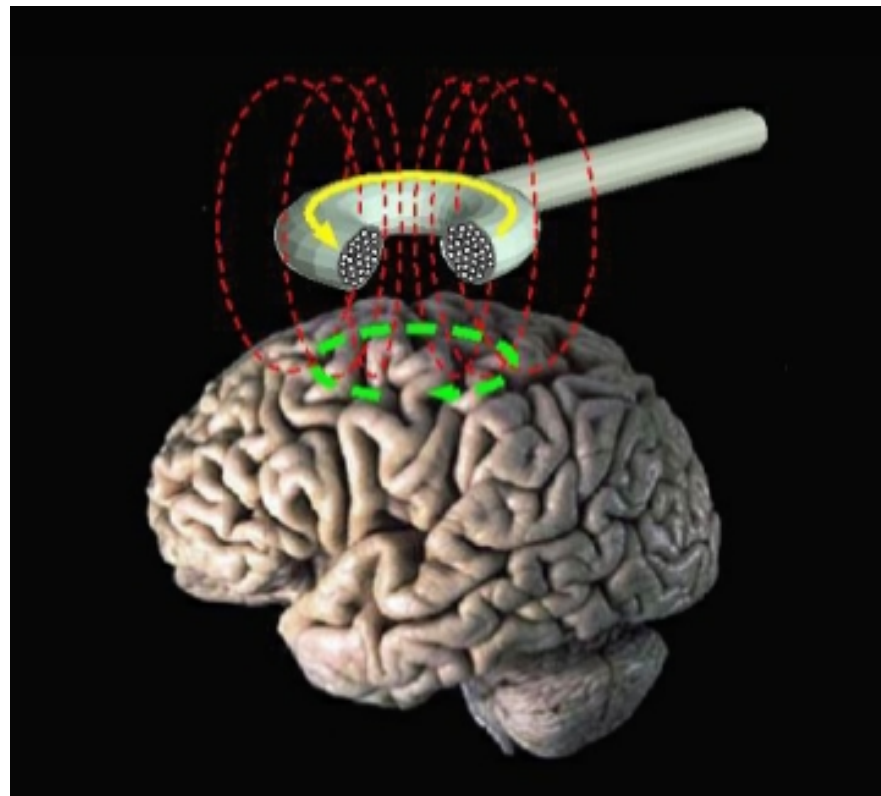


- What pathway: how we identify objects
- Where pathway: how we locate those objects
- When pathway: how we compute *when* visual events occur

Introduction

- ▶ There is **enormous range of neural functions**, from the microsecond delays of auditory processing to the measure of the seasons
- ▶ Some suggest an **internal clock model**: common neuronal mechanism for all timing operations, from visual to speech perception to timing a wide range of motor tasks
- ▶ Others suggest that timing is distributed among **different neural structures** ranging from microseconds processing to millisecond
- ▶ There are two broad classes of temporal analysis at these longer scales:
 - ▶ **metric** - the judgment of duration or interval between events
 - ▶ **ordinal** - the judgment of order of events in a series (in this experiment)

Transcranial magnetic stimulation (TMS)

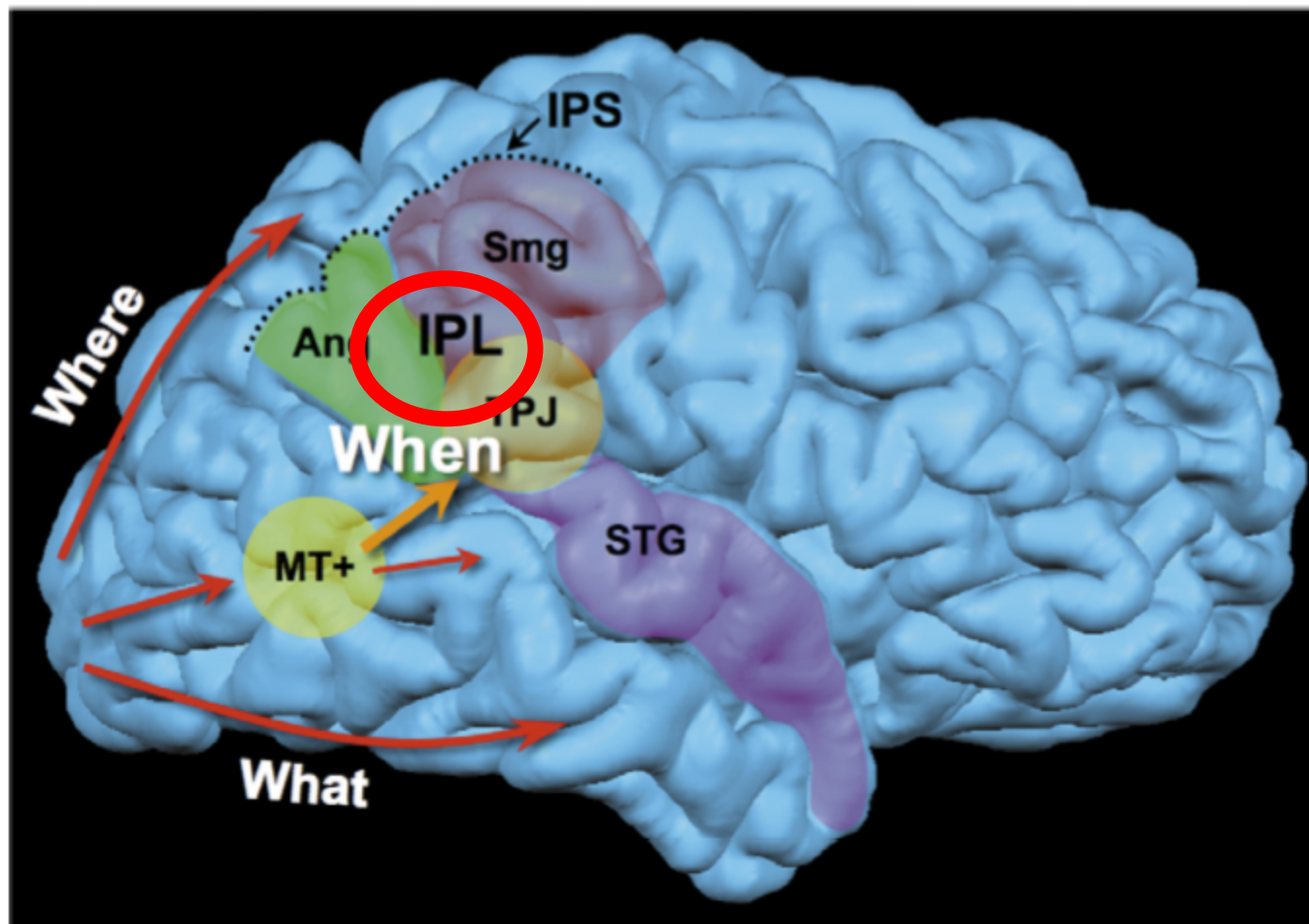


- In this experiment they used TMS to show temporal attention is lateralised via disrupting the **electrical impulses** produced in right parietal lobe. (proposed as when pathway)

Patients with lesion:

- ▶ They not only used TMS, they also used patients with **lesion**.
- ▶ **Parietal control** over spatial attention is strongly **contralateral**, whereas the control of the **right parietal cortex** over temporal attention is **bilateral**: So different mechanisms?
- ▶ The difference between **bilateral** and **contralateral** effects is then **diagnostic** of the contributions of spatial and temporal attention in tasks where both are involved

The processing of the temporal dimension



Inferior Parietal Lobe:

- has a major role in detecting visual events at **unexpected locations**
- studies on patients who have **lesions in the right IPL** suggest a specific role for this area of the brain in perceptual abilities that require the **analysis of time**

IPL: Its principal functions are related to perceptual-motor coordination (e.g., directing eye movements and reaching) and visual attention, which allows for visually-guided pointing, grasping, and object manipulation that can produce a desired effect.

Event order and high-level motion

Low level system

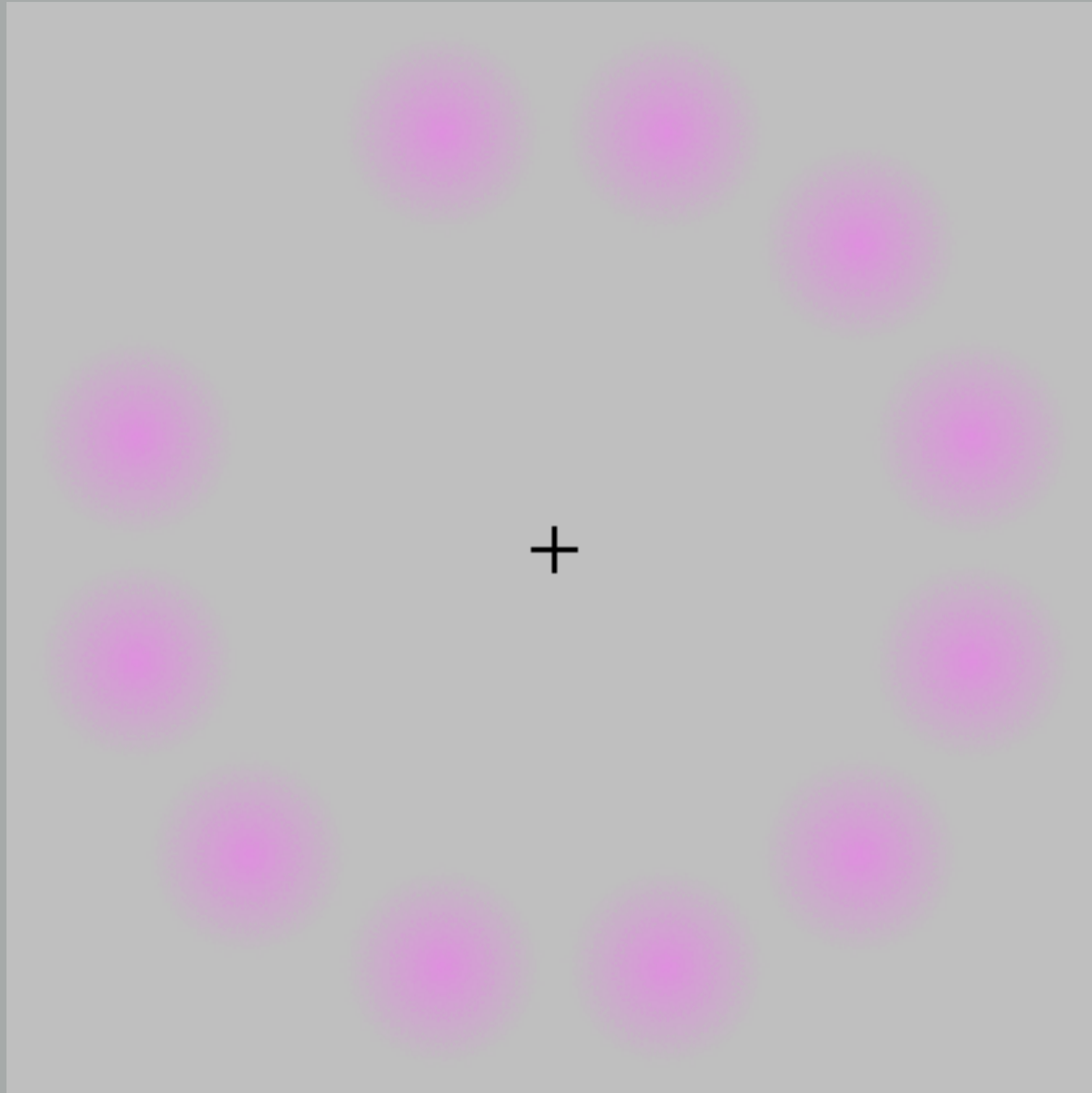
- ▶ motion based on the direction selectivity of neurons in the primary visual cortex
- ▶ triggered by subsequent stimuli falling within their receptive field.

High level system

- ▶ ‘cognitive’ attention-based
- ▶ motion perception when motion must be perceived between a set of **discrete** stimuli that are flashed in sequence, separated by long space and time intervals
- ▶ when motion is revealed by attentive **tracking**

low- and high-level motion systems are anatomically and functionally distinct

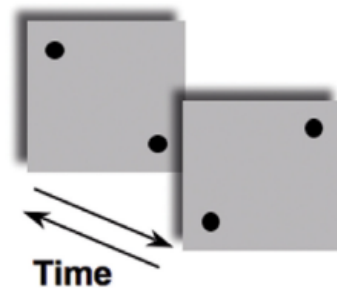
i.e. High-Level Motion System (Lilac Chaser Illusion)



Apparent Motion

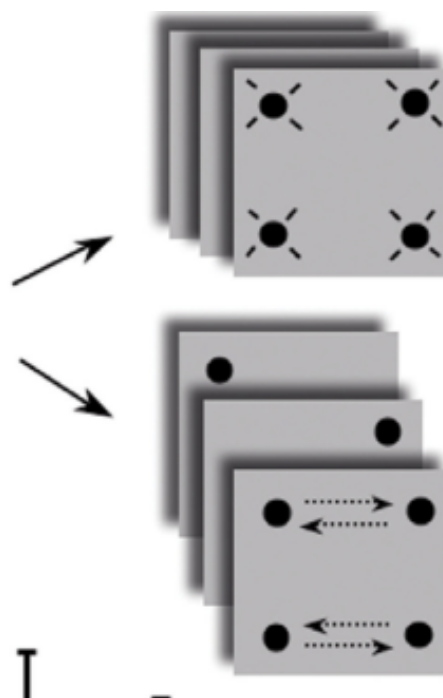
Apparent motion task: Two frames with two dots each are alternated at a variable frequency

(a)



At appropriate time intervals (around a frequency of alternation of 7 or 8 Hz), subjects report motion

Percept

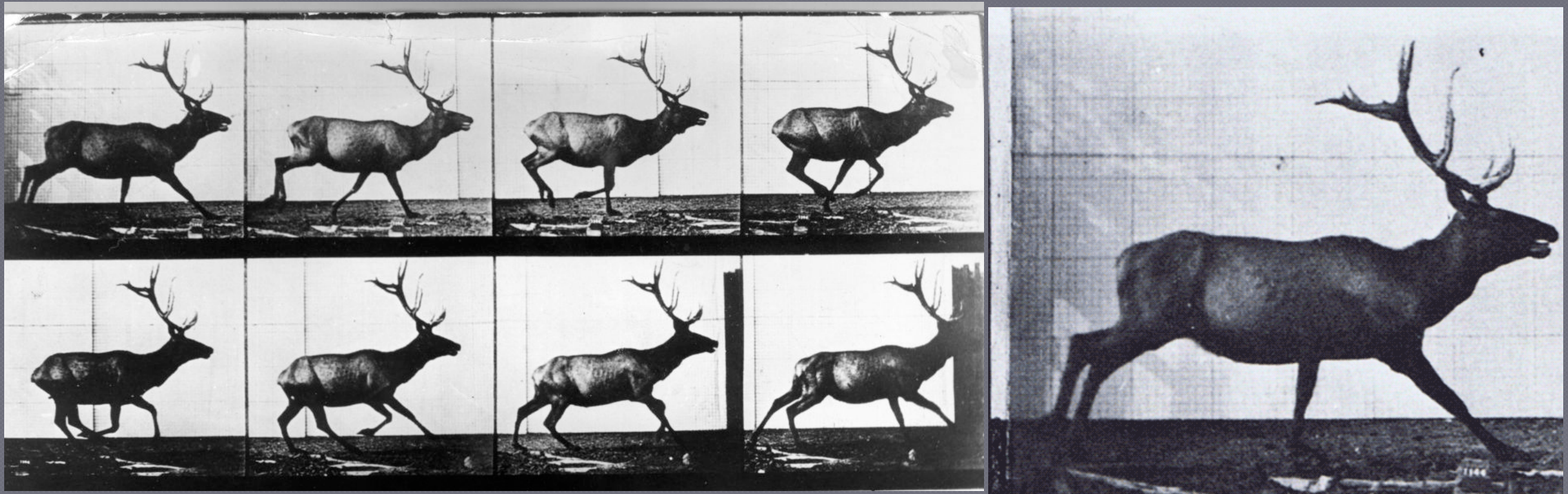


When the interval between the frames is very short (at high frequency, >10 Hz), subjects can perceive only flickering dots and no motion is reported

Apparent Motion

Eadweard Muybridge, 19th century

English photographer important for his pioneering work in photographic studies of motion, and early work in motion-picture projection



He invented **zoopraksiskop** device accepted as the first projector device.

Today, films are composed of 24 snapshots per second.

The right parietal lobe and bilateral control of transient attention

- ▶ Attentional mechanisms are involved in the **perception of apparent motion**
- ▶ Both spatial and temporal properties determine the **perception of apparent motion** and this enables us to:
 - ▶ ask whether visual **spatial and timing functions** are sub-served by the same **high-level neuronal substrates**
 - ▶ or whether they are **distinct** functions in the brain
- ▶ Spatial deficits following parietal damage are typically lateralized but other deficits, **specifically temporal ones, have been found to be non-lateralized (bilateral)**