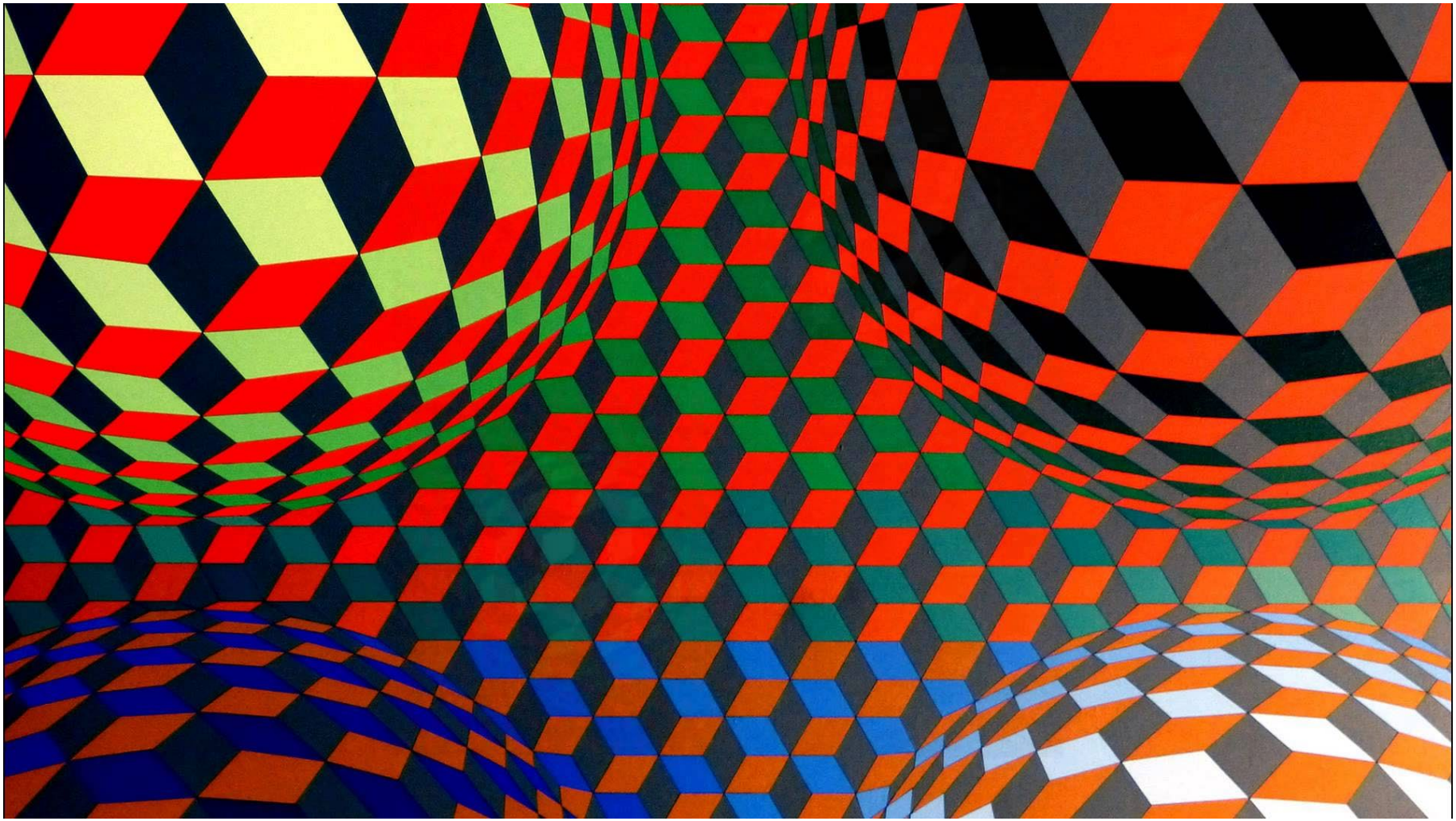
# Visión por Computador

## T1. Introducción a la Visión por Computador

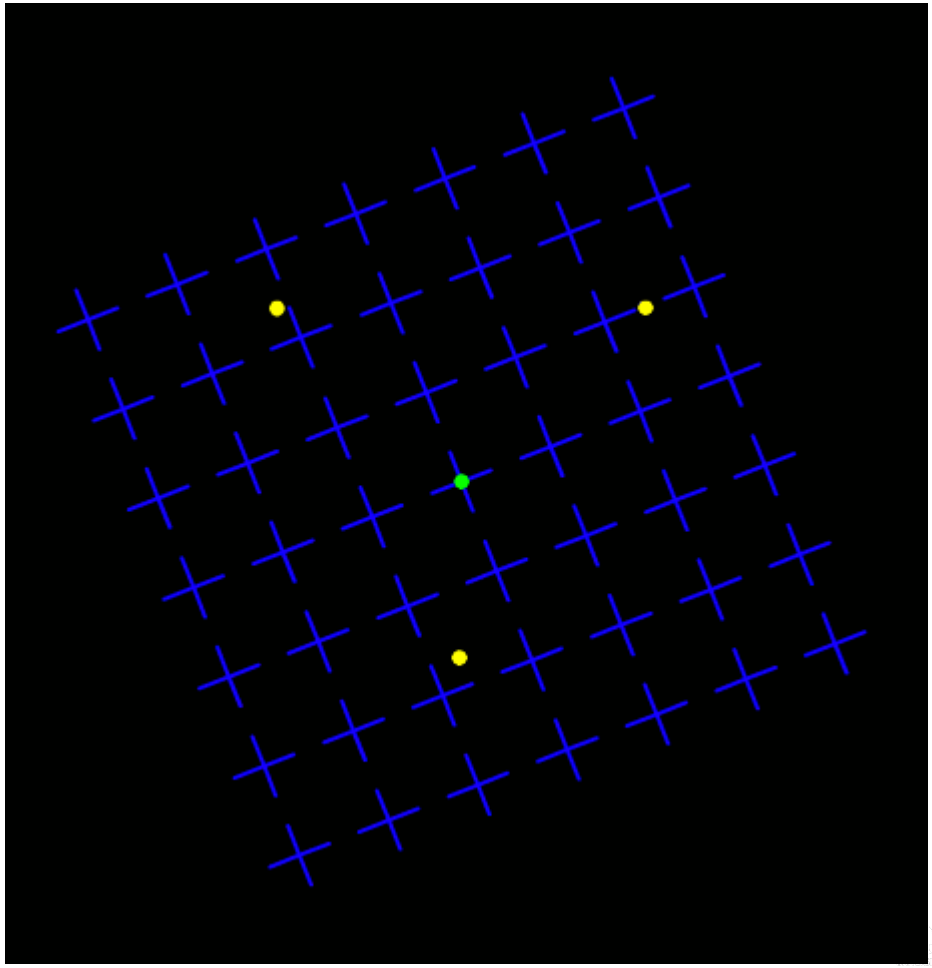


Victor Vasarely

EII, GII. *Modesto Castrillón Santana*

# Contenidos

- Introducción
- Percepción
- Aplicaciones



Ilusión de Bonneh

# Definiciones

**Visión** es el *proceso de descubrir lo que está presente en el mundo y donde está, a partir de imágenes del mismo.*

(David Marr, 1982)

# Definiciones

**Visión por computador:**
*Métodos para adquirir, procesar, analizar y comprender las imágenes del mundo real con el fin de producir información numérica o simbólica para que puedan ser tratados por un computador.*

[Terminator Vision](#) (1984)

# Definiciones

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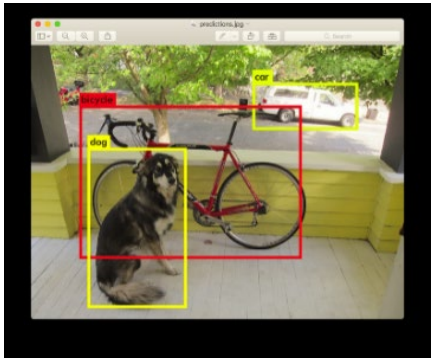
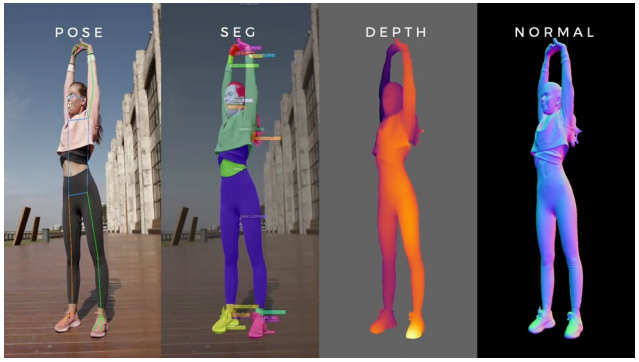
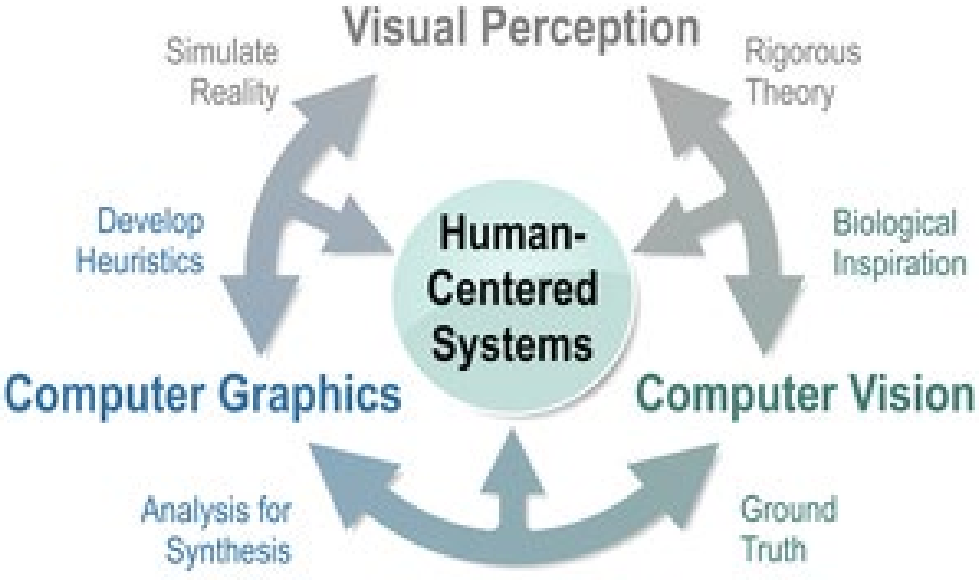


# Definiciones

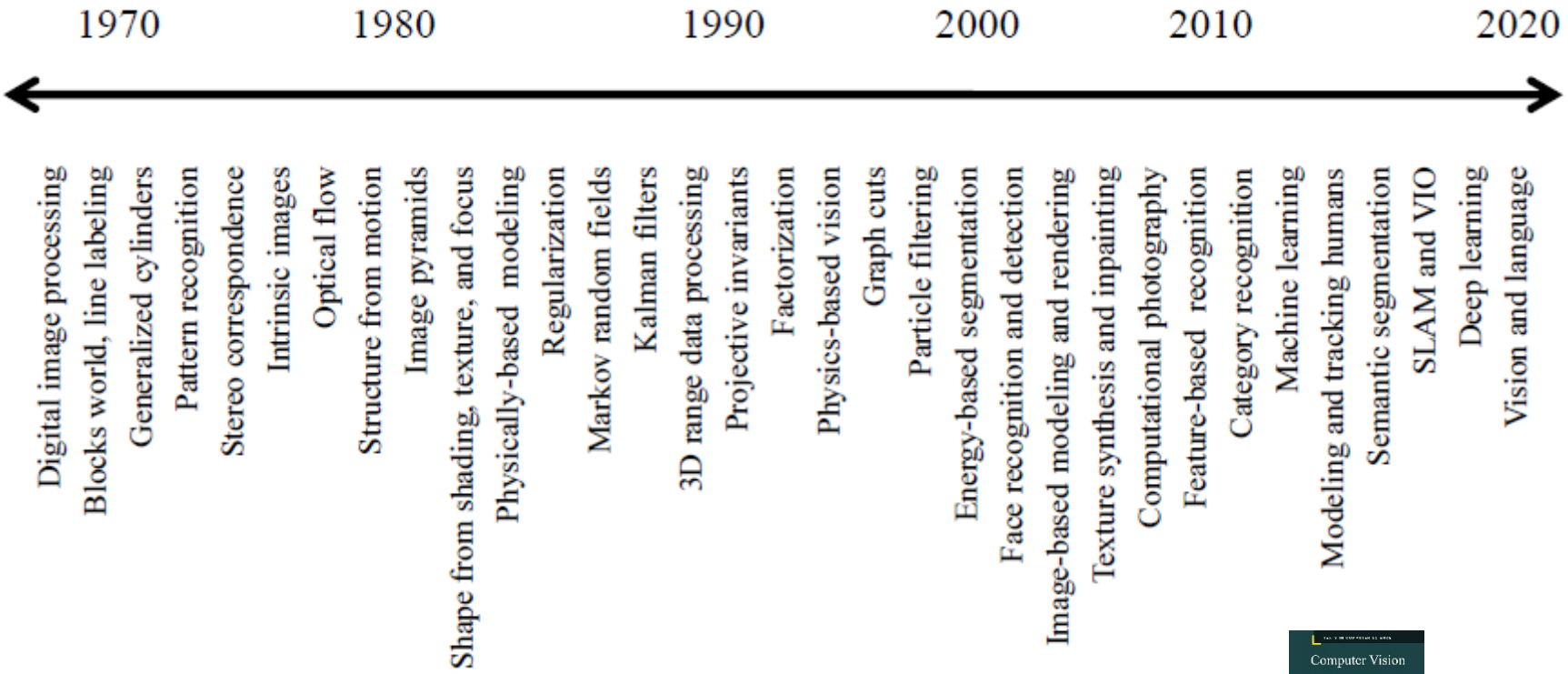
**Visión por computador:**

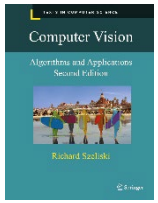
- Comprensión de la imagen (IA)
- Modalidad sensora de la robótica
- Emulación de la visión humana
- Inverso a los gráficos por computador



# Definiciones

## Visión por computador:

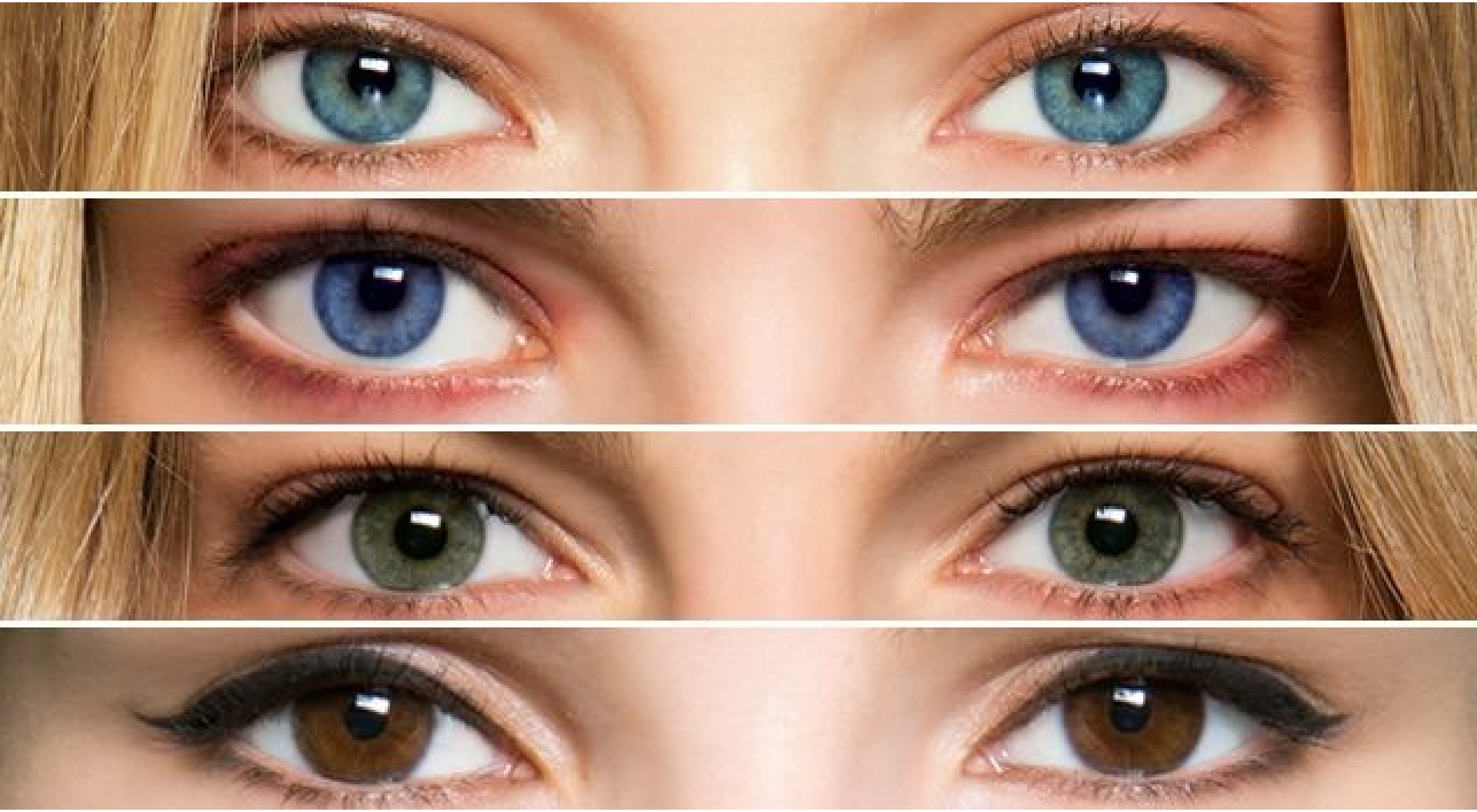



Szeliski

# Introducción

# Percepción

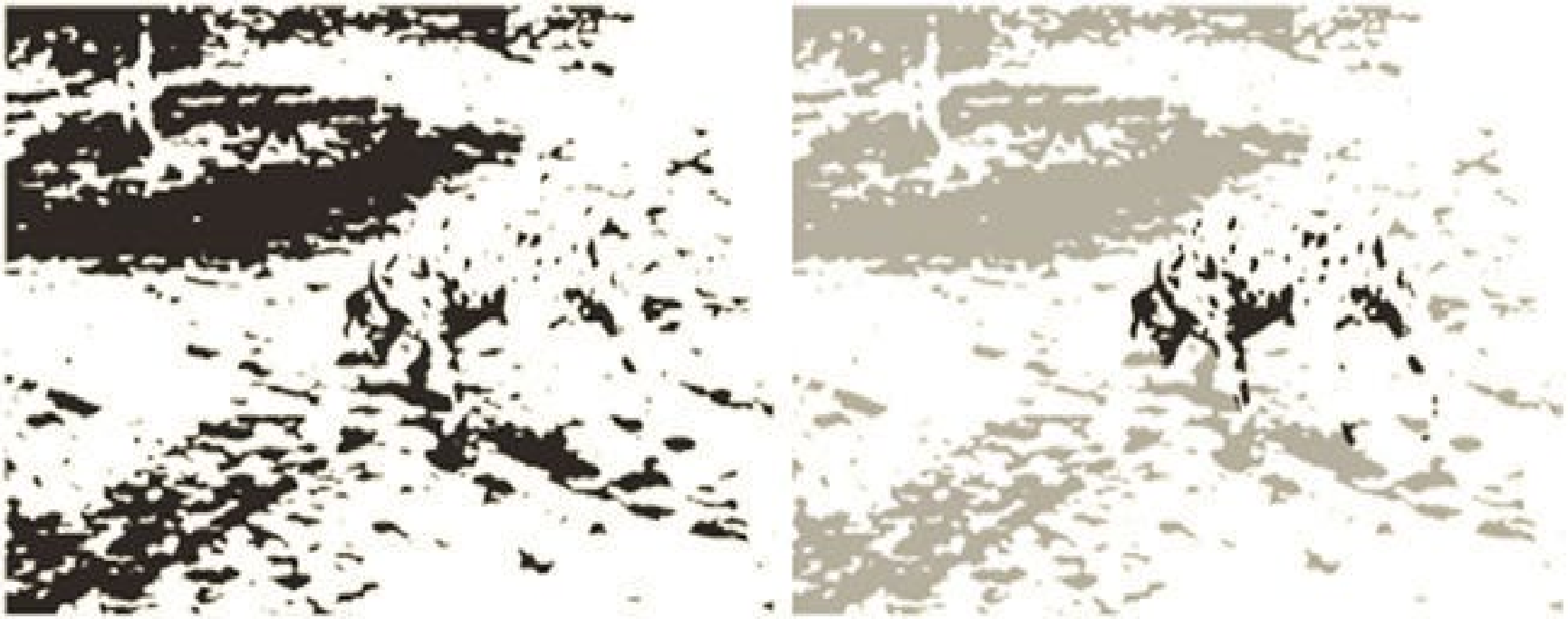


# Percepción

# Percepción

Percepción

Percepción



# Percepción

JR, *Portrait of a Generation*

# *El instante decisivo*, Henri Cartier-Bresson

# Percepción

H. Cartier-Bresson

# Percepción

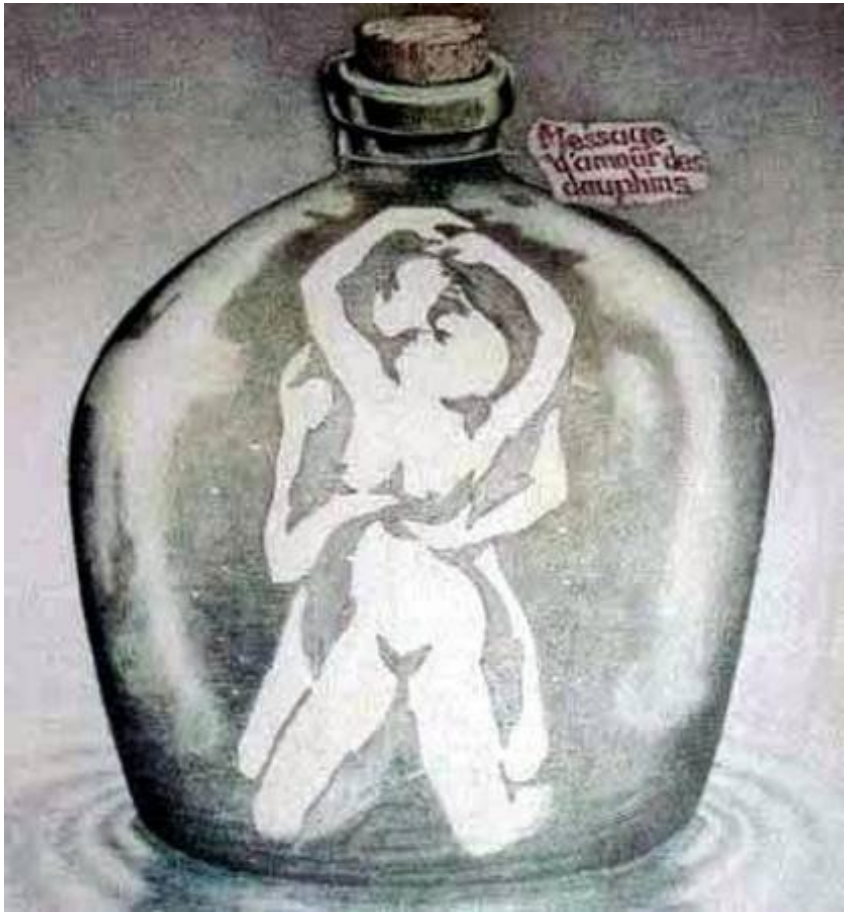
H. Cartier-Bresson

¿Vemos o buscamos?

Esperado vs. no esperado

¿Vemos o buscamos?

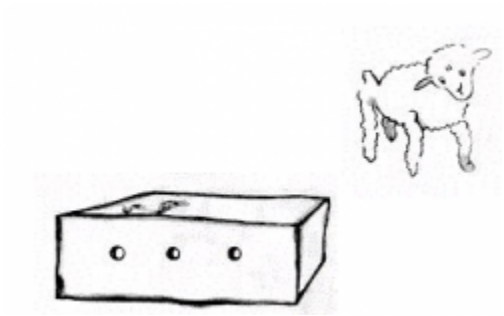
Esperado vs. no esperado

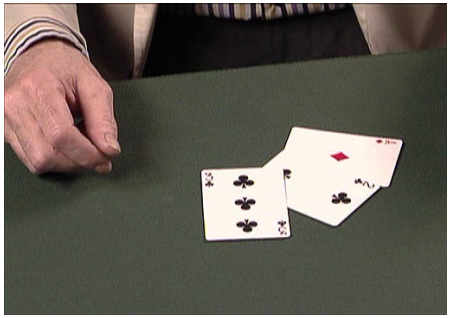


Capacidades humanas

Impresiones visuales: excitación neuronal y pasado cognitivo

Emociones y reacciones distintas en diferentes individuos





¿Cuántas X?

¿Cuántas X?

X X X X X X X
X X X X X X X
X X X X X X X
X X X X X X X
X X X X X X X
X X X X X X X
X X X X X X X
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X X X X X X X
X X X X X X X

¿Cuántas X?

| | | | | | | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | X | X |
| X | X | X | X | X | X | X |
| X | X | X | X | X | X | X |
| X | X | X | X | X | X | X |
| X | X | X | X | X | X | X |
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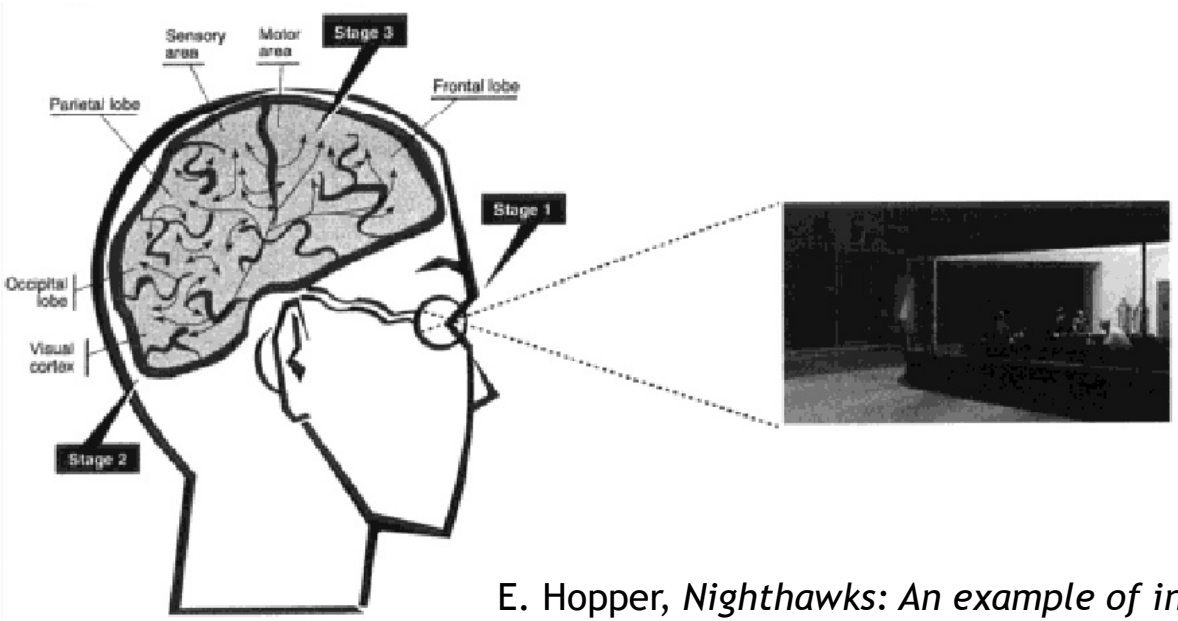
| X | O | X | X | X | O | X |
| O | X | X | O | X | X | O |
| X | X | O | X | O | O | X |
| O | X | X | O | X | X | X |
| X | O | X | X | X | O | X |
| O | X | X | O | X | X | O |
| X | O | X | X | X | O | X |
| X | X | X | O | O | X | X |
| X | O | X | X | X | O | X |

A. Treisman

# Modelo teórico procesamiento de información:

- Procesamiento retinal
- Nervio óptico, impulsos neuronales al córtex visual: primitivas (ángulos, líneas, ...)
- Zonas cerebrales reciben y procesan en paralelo




E. Hopper, *Nighthawks: An example of information processing*

# Niveles de D. Marr:

- Retina: bordes y regiones
- 2D ½
- Modelo 3D

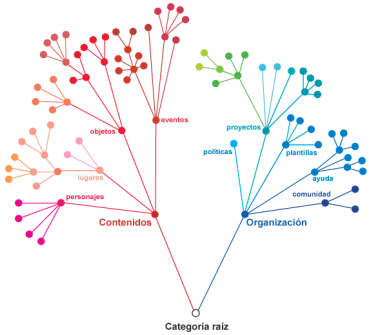



Imagen retinal

↓

Procesamiento imagen

↓

Procesamiento superficies

↓

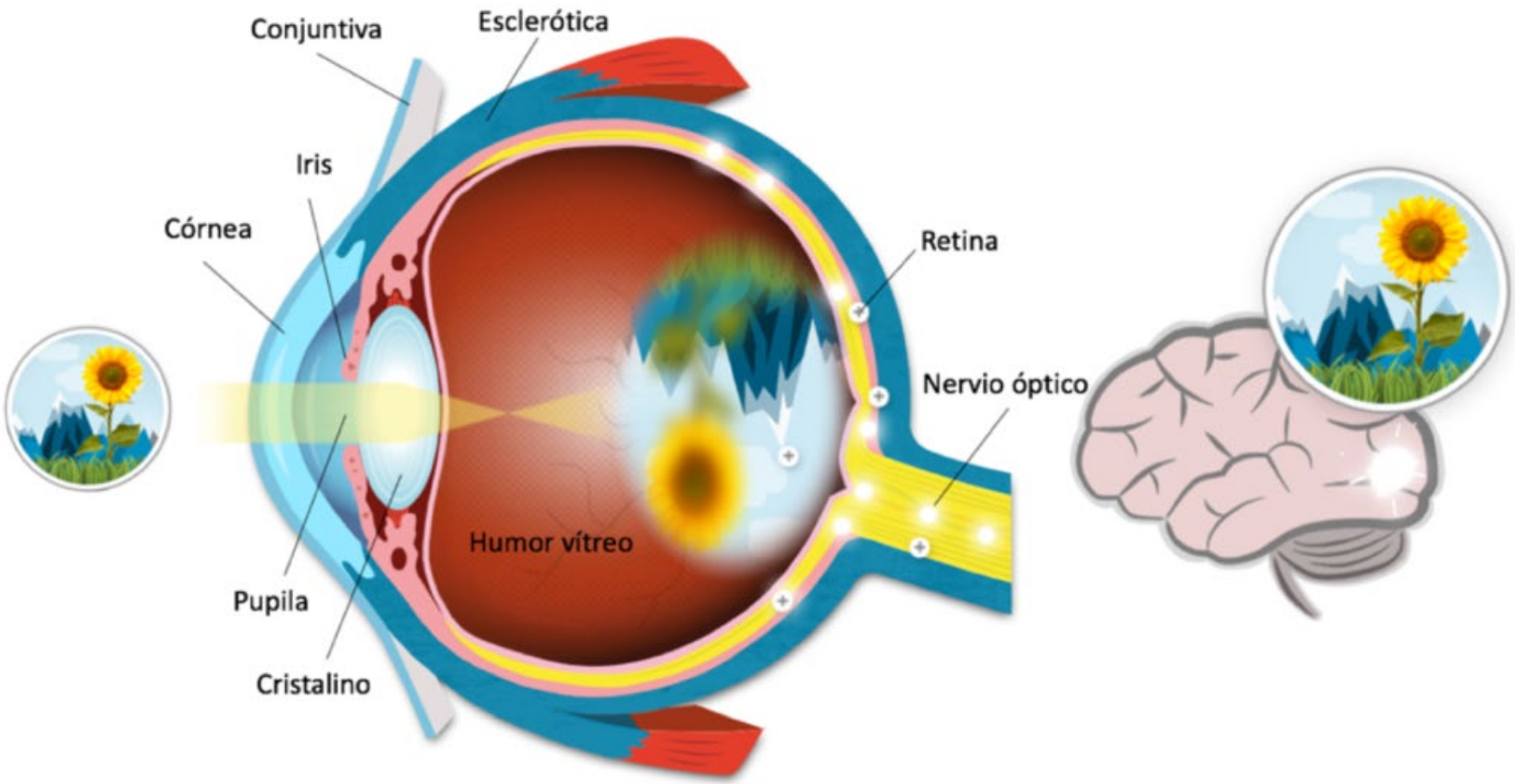
Procesamiento objetos

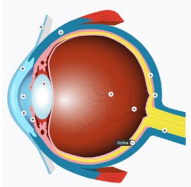
↓

Procesamiento categorías

↓

# Ojo humano

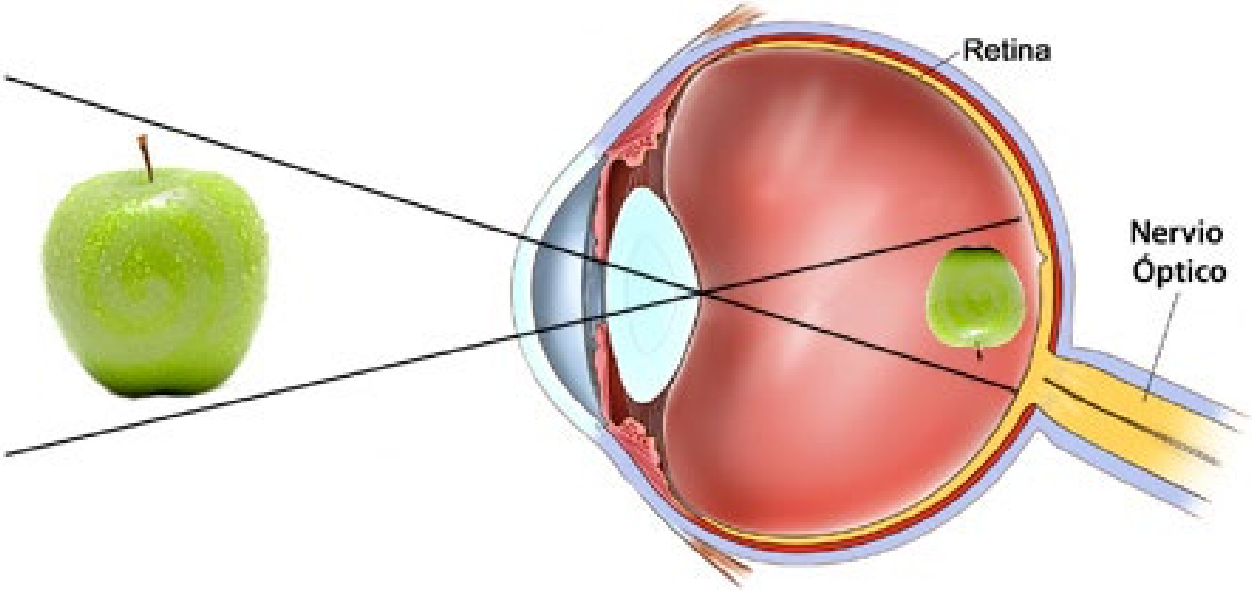

Conjuntiva
Esclerótica
Iris
Córnea
Retina
Nervio óptico
Humor vítreo
Pupila
Cristalino



# Ojo humano

Luz reflejada llega a la retina

Proyección, modelo *pinhole*



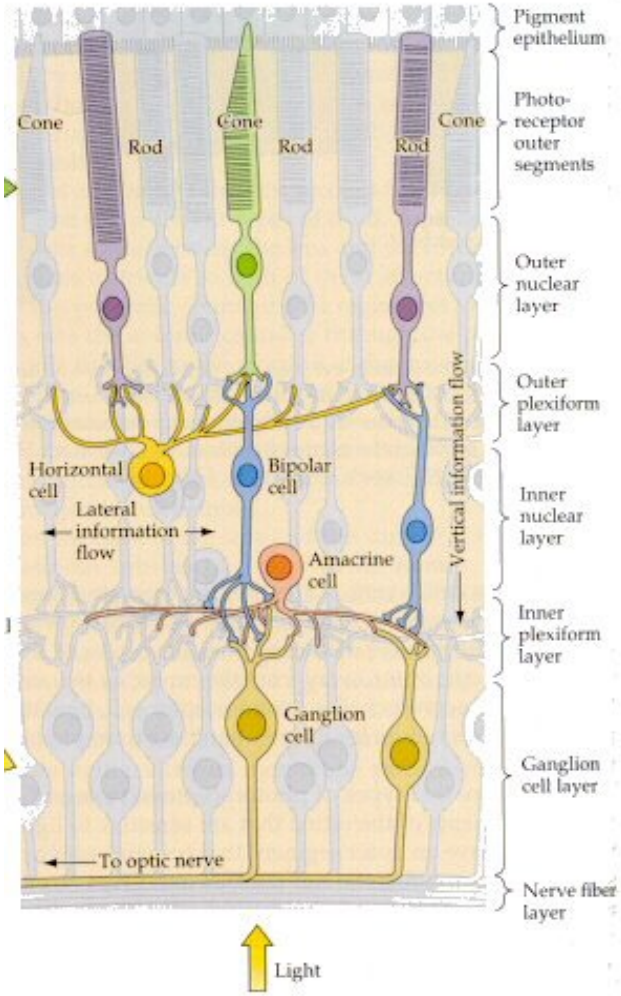
# Ojo humano

En retina

Información niveles de luz y color

Convierte en actividad neuronal

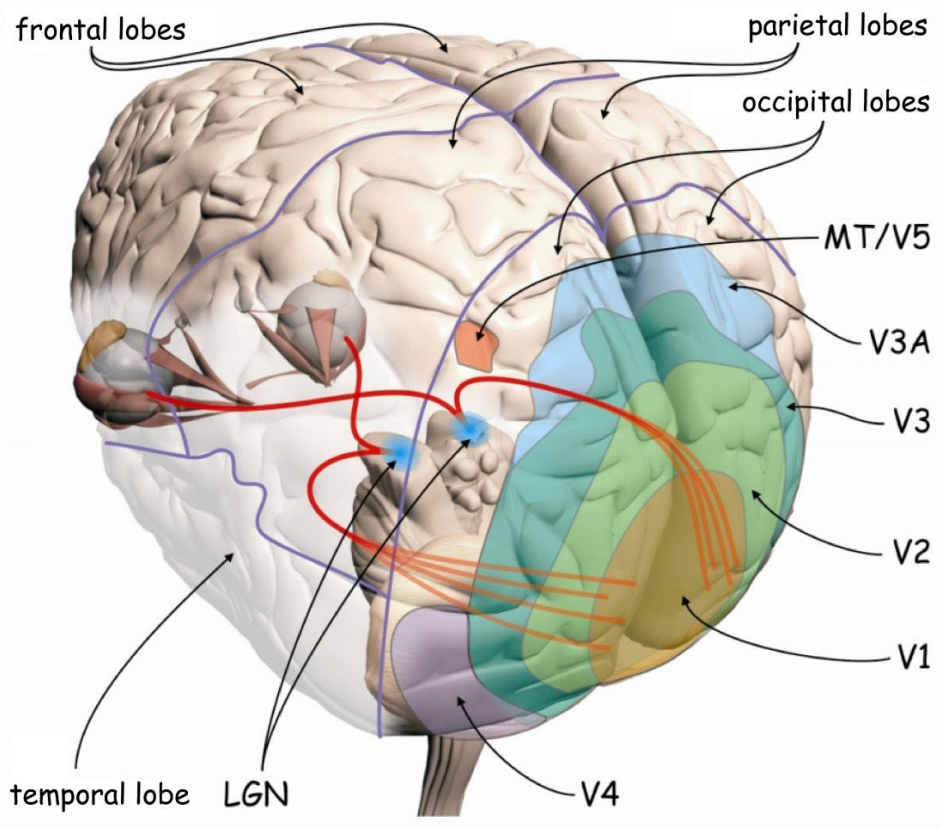
- Cambios físicos y químicos
- Impulsos eléctricos



# Ojo humano

Cerebro transforma “lo visto”, construye “lo percibido”

Divide y vencerás para reducir

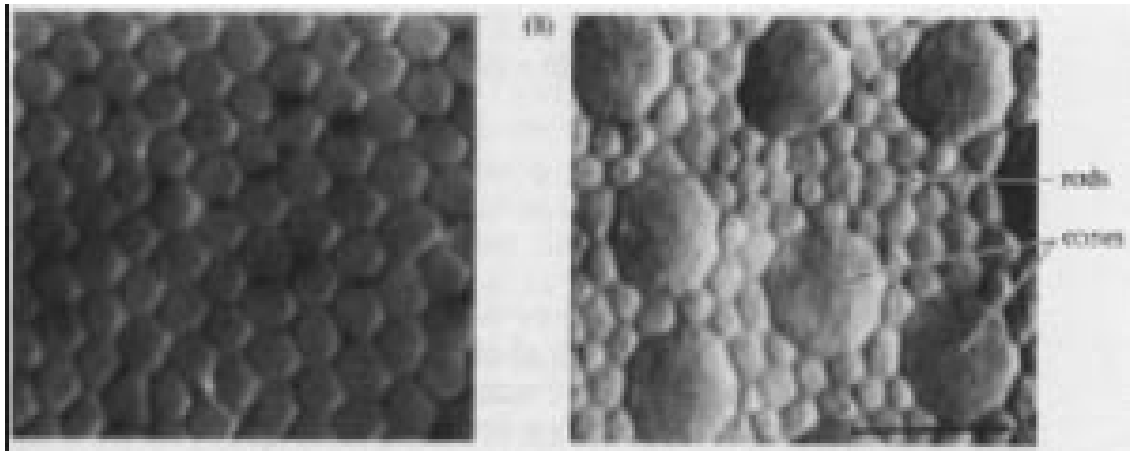



Logothetis y Zeki

# Ojo humano

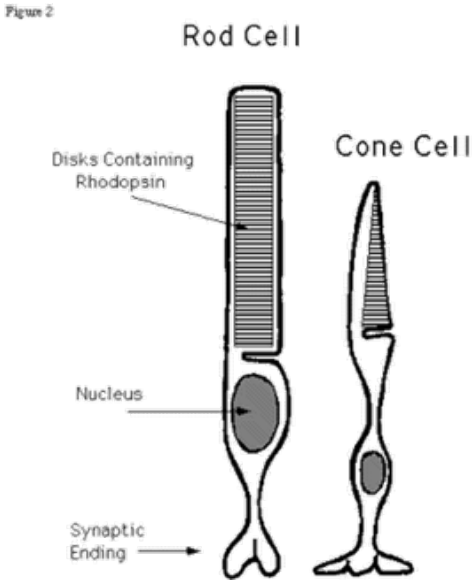
Fotorreceptores:

- **Conos** ($7x10^6$): Altos niveles de luz, brillo, detalles y color
- **Bastones** ($100x10^6$): Bajos niveles, nocturna, sin color, no fóvea



Fóvea (conos)

Periferia (conos y bastones)



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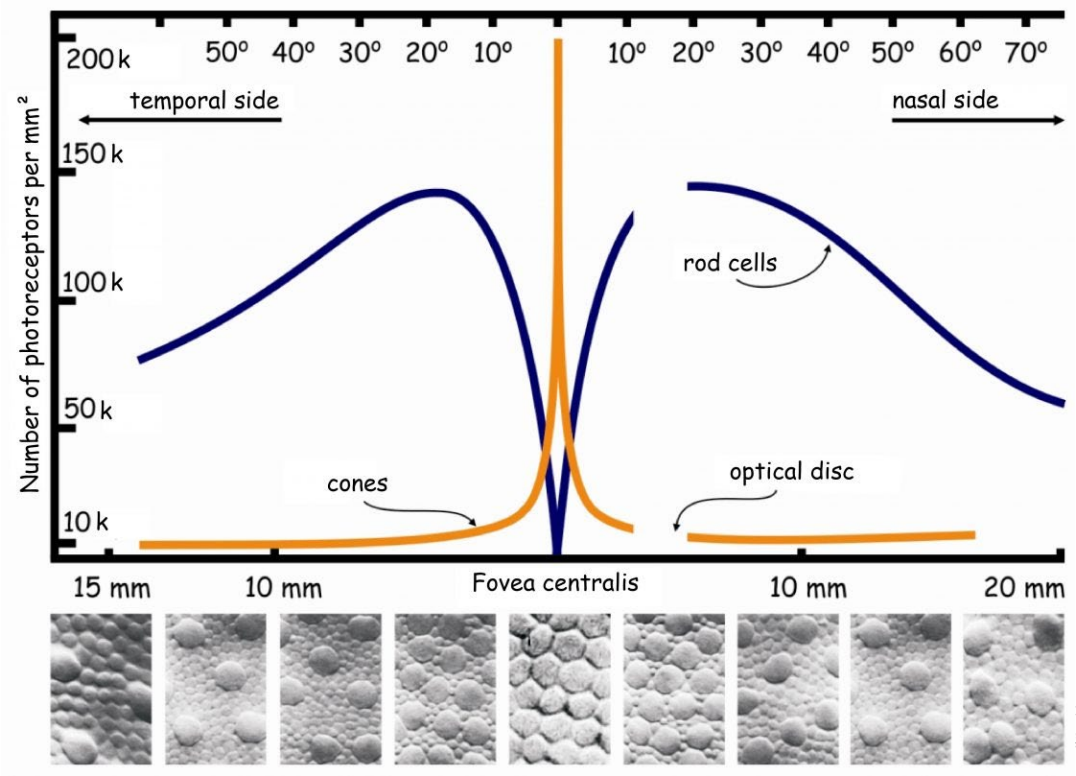
Distribución dispar

+ conos en fóvea

Punto ciego

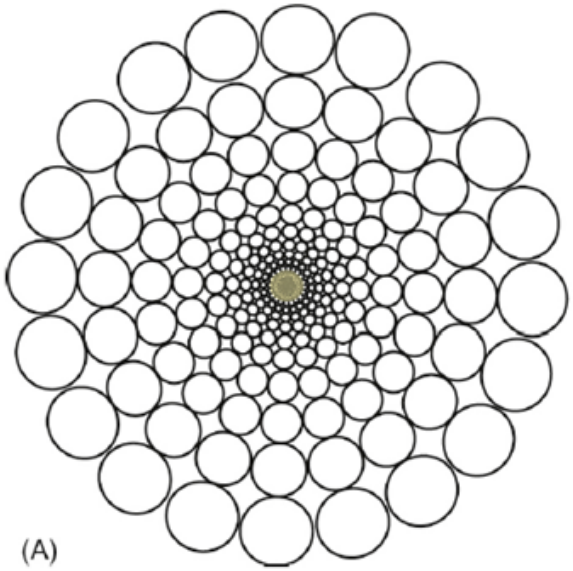


# Ojo humano

No uniforme

Capacidad de visión irregular:

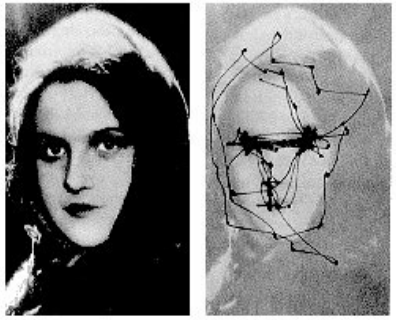
- Precisión máxima en la fóvea, 2º
- Limitada en el resto, visión periférica



(A)

(B)

# Ojo humano

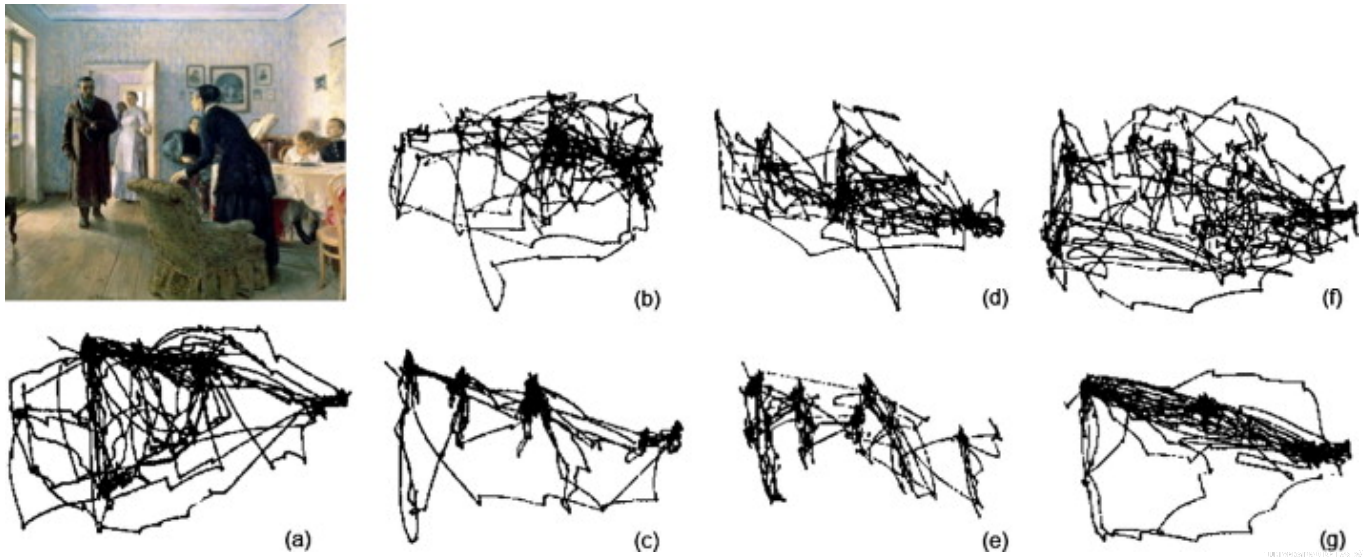


Focalización de la fóvea, movimientos:

- del cuello
- del globo ocular (lentos)
- rápidos e inconscientes del globo ocular (*sacádicos)*

Movimientos oculares según tarea:

- a libre
- b riqueza
- c edad
- d actividad
- e ropa
- f recordar
- g elaborada

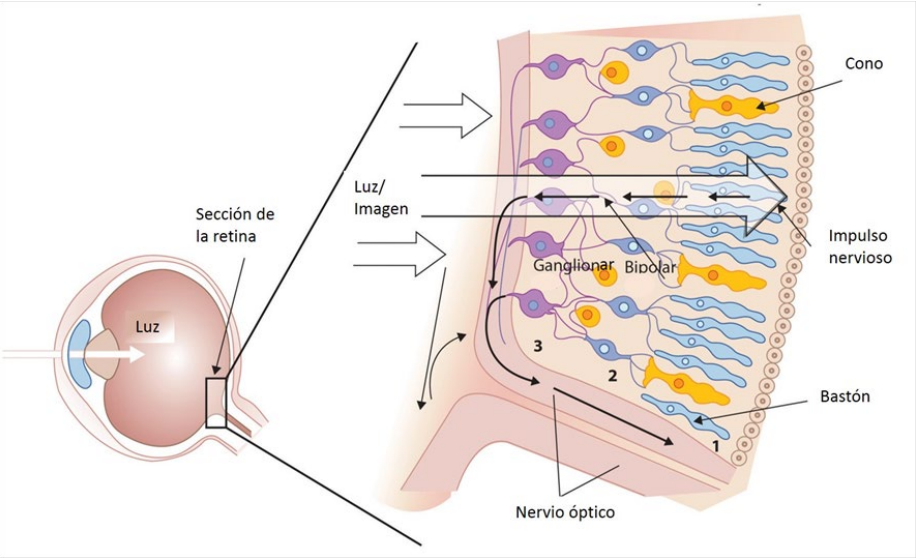


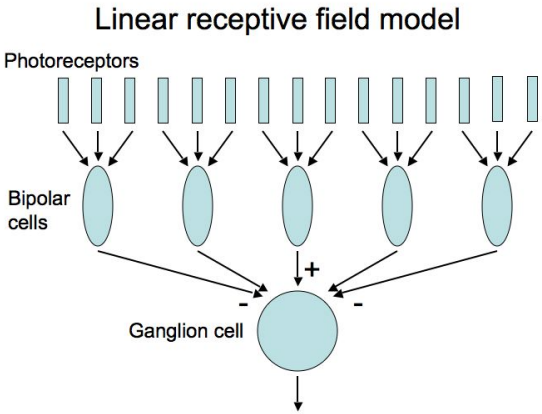
# Ojo humano

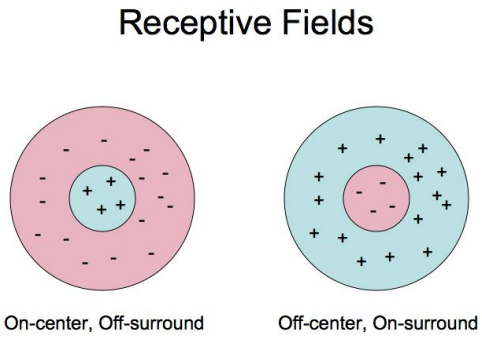
Neuronas especializadas conectan grupos de fotorreceptores

Células ganglionares conforman el nervio óptico

Campo receptivo células ganglionares



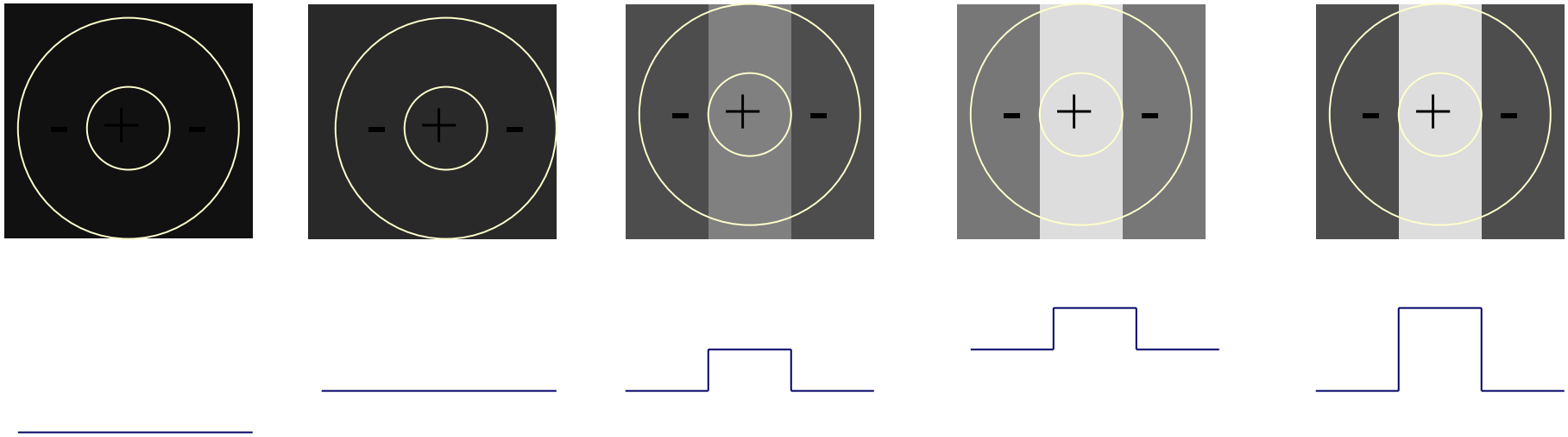



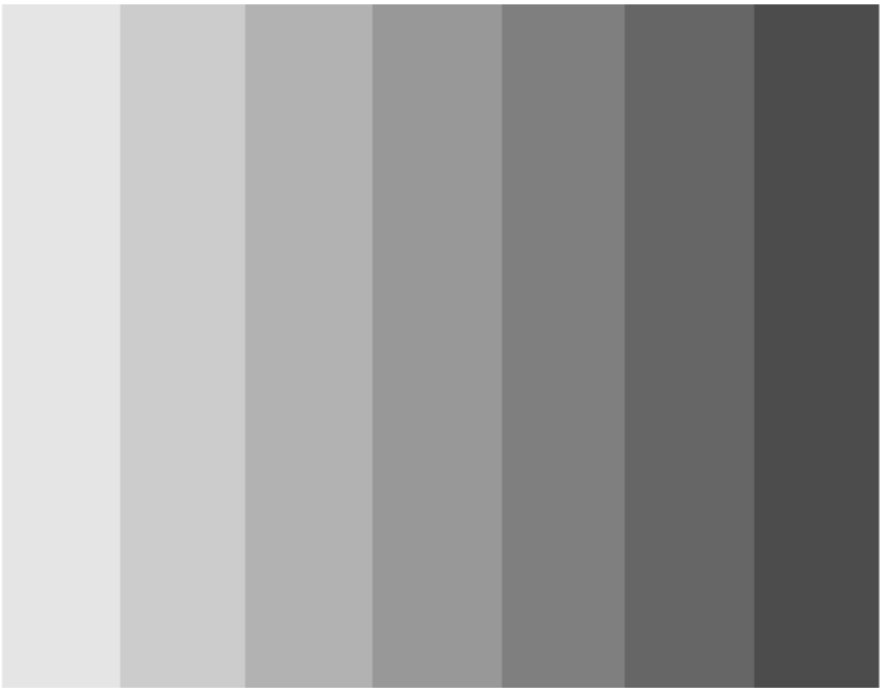
# Ojo humano

Configuración campos receptivos

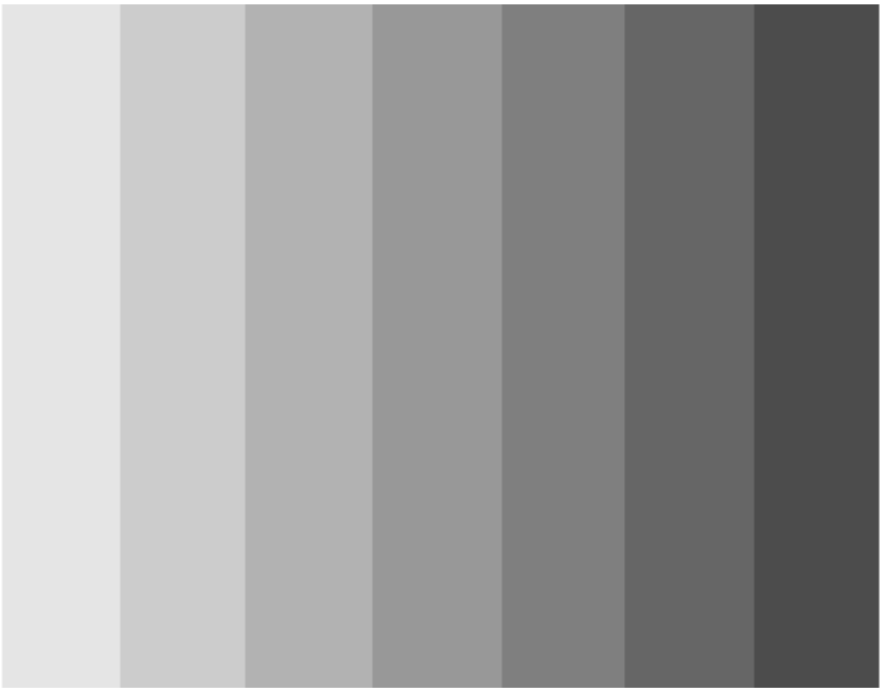
Mayor respuesta a contraste que a intensidad

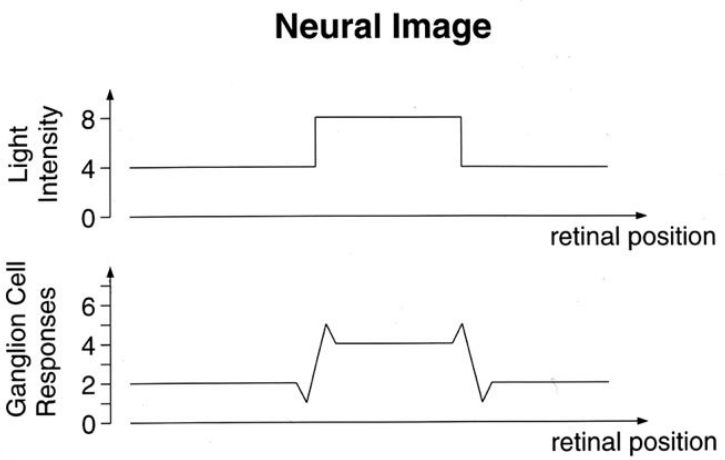


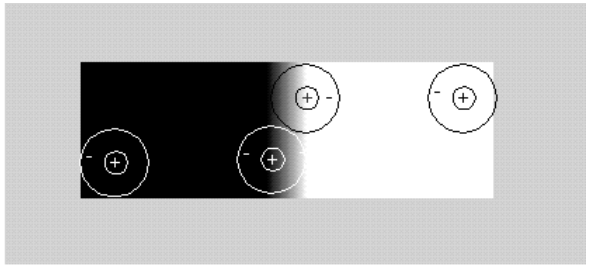
# Ojo humano

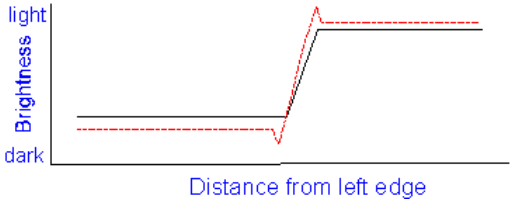


# Ojo humano




Neural Image
Light Intensity
8
4
0
retinal position
Ganglion Cell Responses
6
4
2
0
retinal position

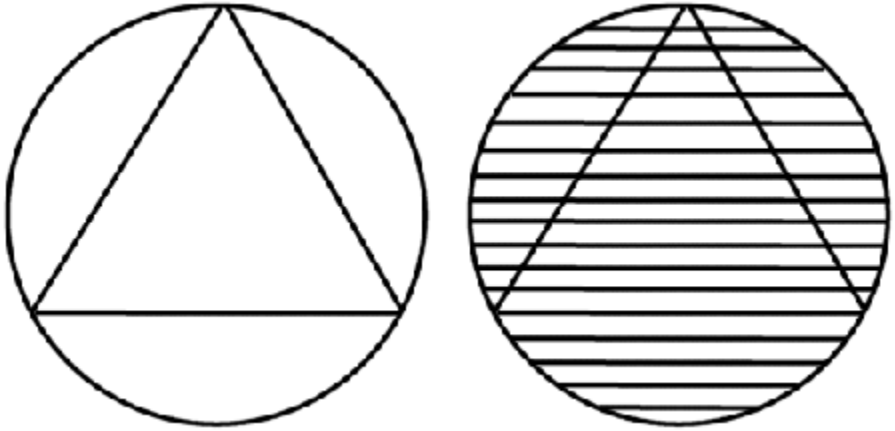



light
Brightness
dark
Distance from left edge

# Ojo humano

Triángulo Galli y Zama (1931)

Filtros de Gabor



# Ojo humano

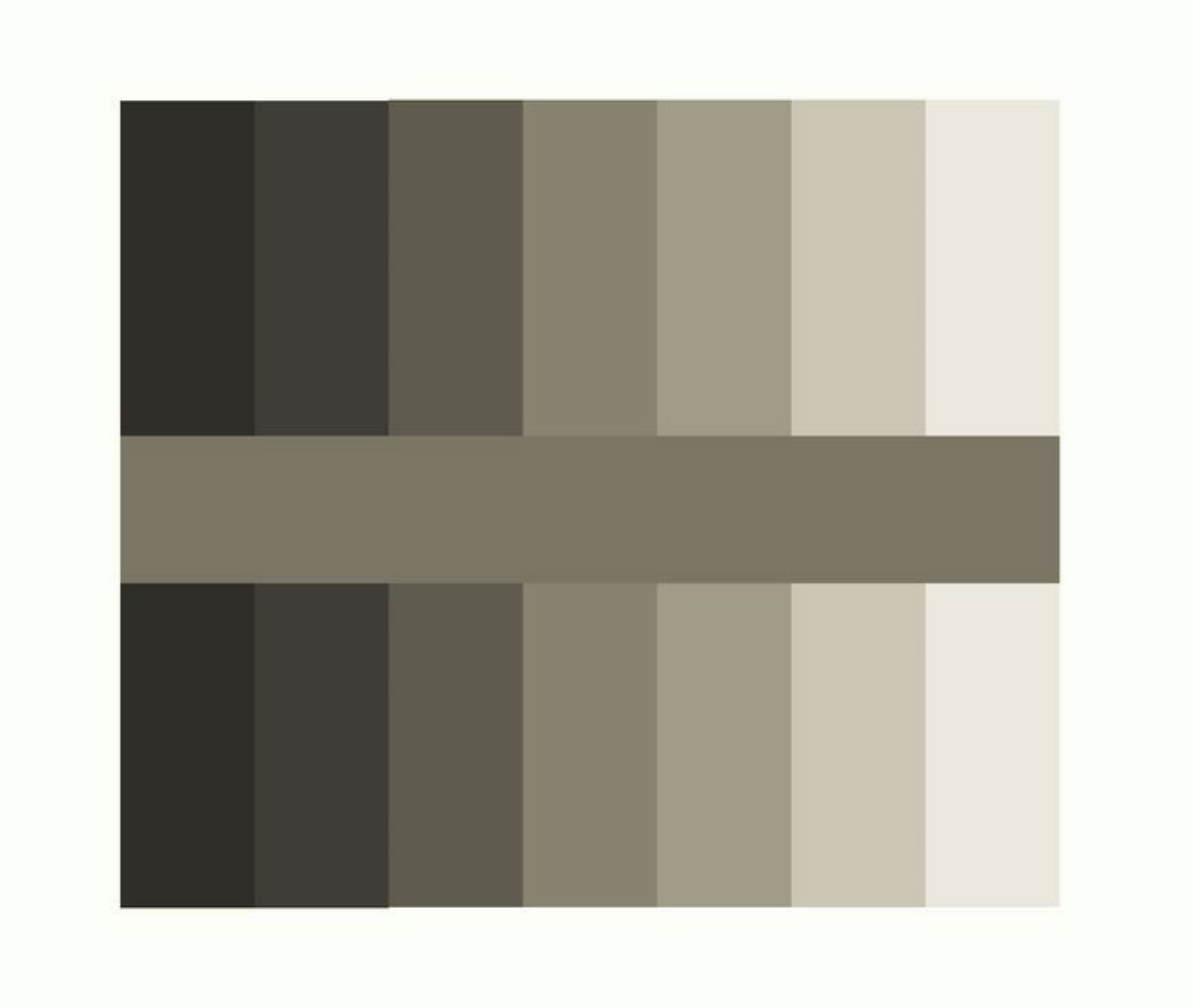
Agudeza visual: distinguir dos líneas (30")

Adaptación: sensibilidad logarítmica

Mayor de noche, ajustes pupila, alteraciones en fotorreceptores y cambios en procesamiento neuronal

# Ojo humano

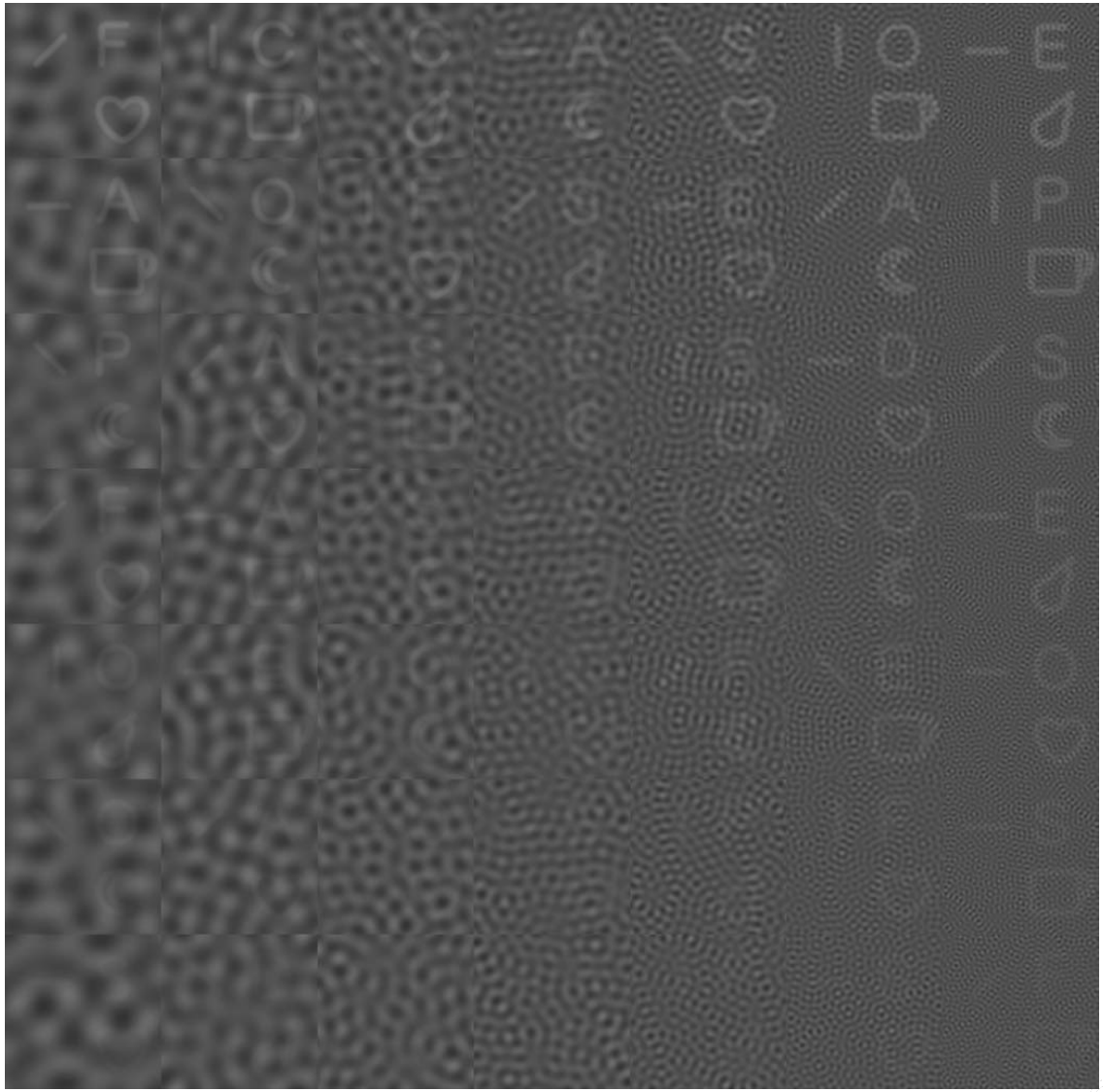
Contexto



# Ojo humano

Contraste

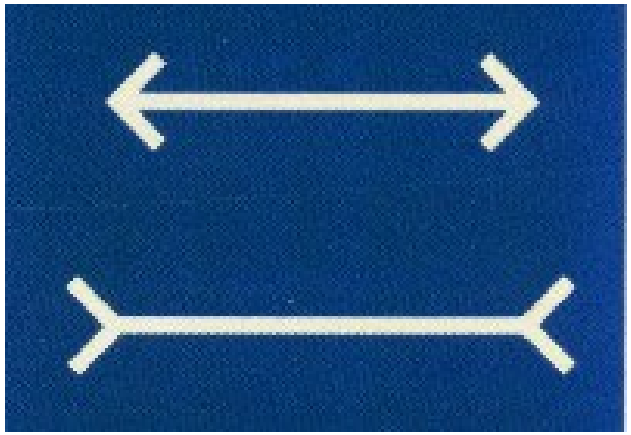
Frecuencia textura



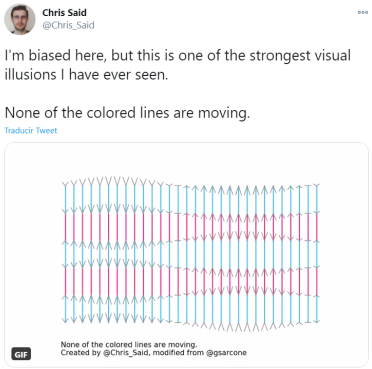
Petkov y Westenberg

# Ojo humano

## Contexto

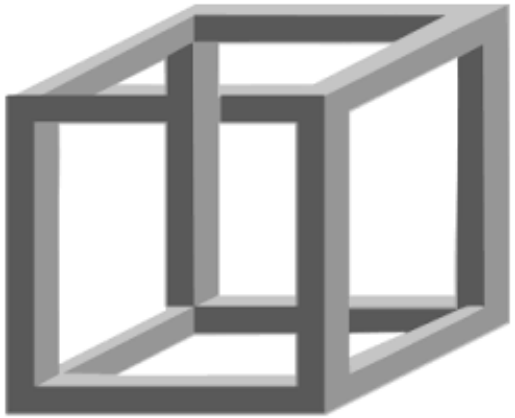


**Ilusión de Müller-Lyer (1889)**

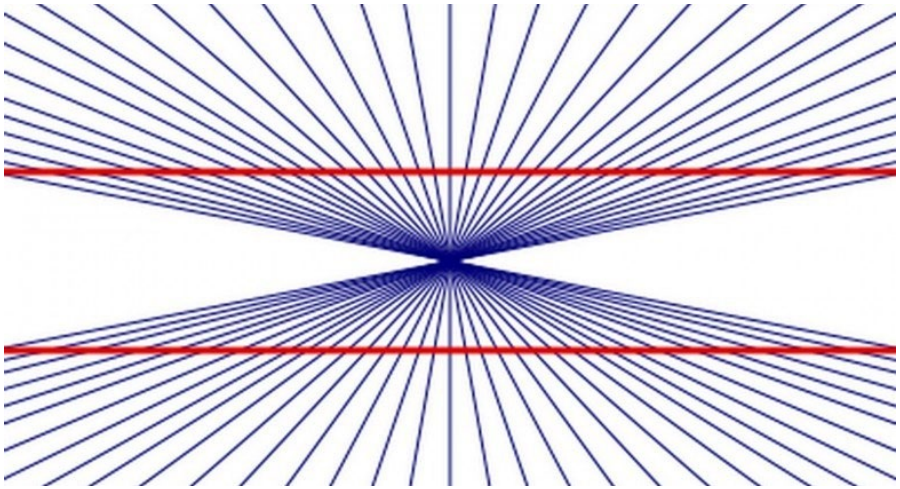


# Ilusiones ópticas

Necker (1832)

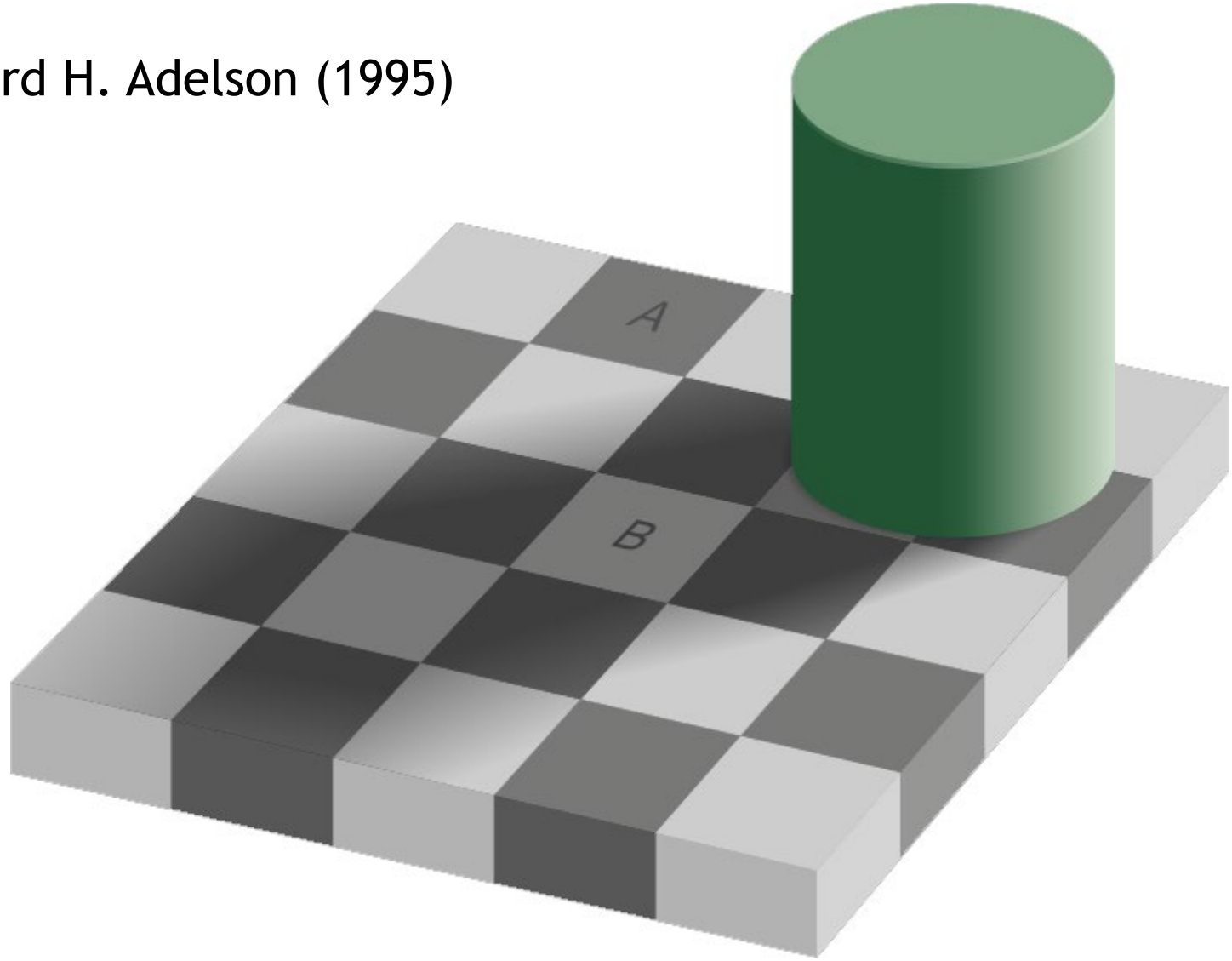


Herring (1861)



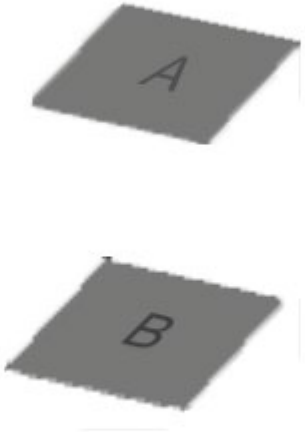
# Ilusiones ópticas

Edward H. Adelson (1995)



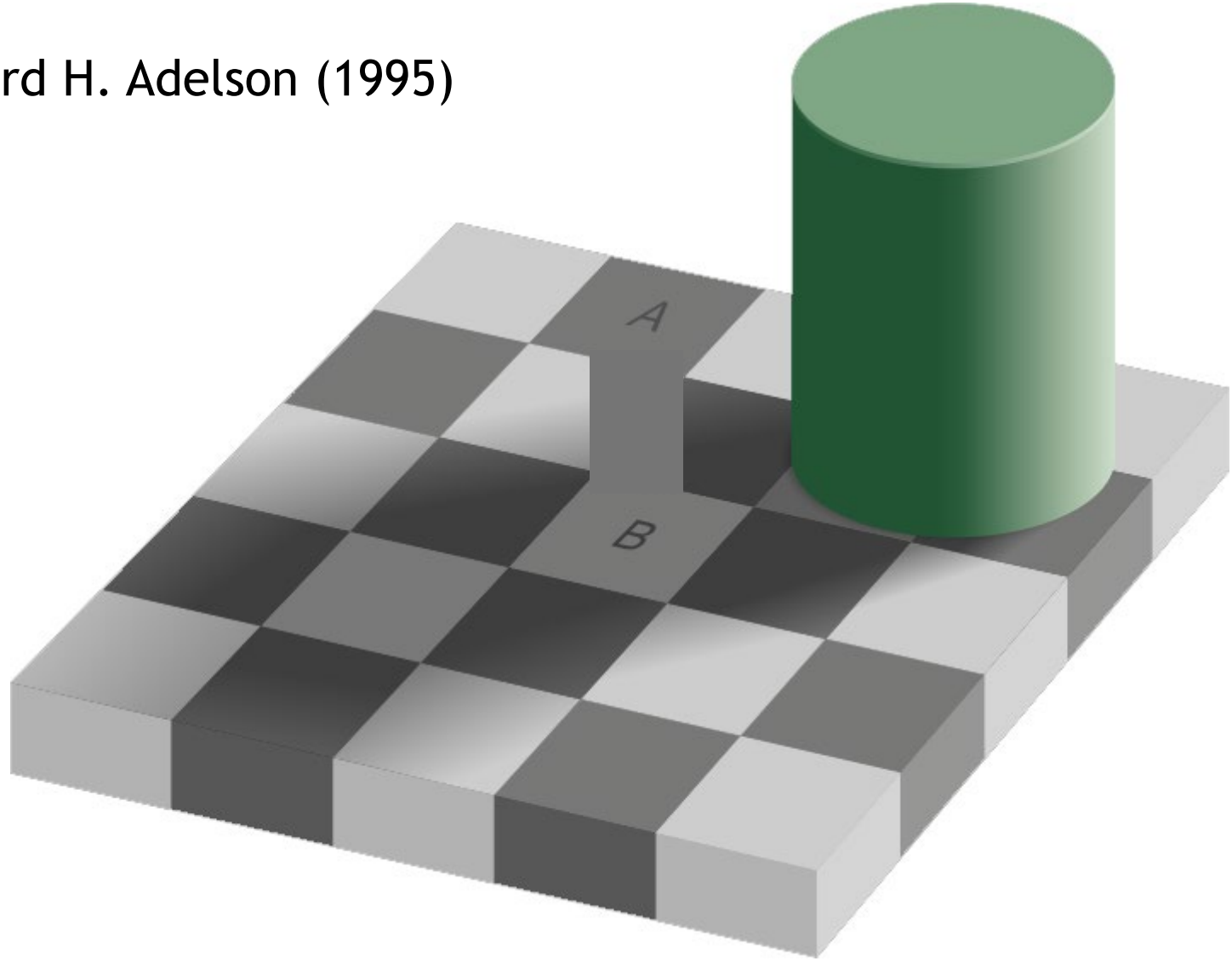
# Ilusiones ópticas

Edward H. Adelson (1995)



# Ilusiones ópticas

Edward H. Adelson (1995)

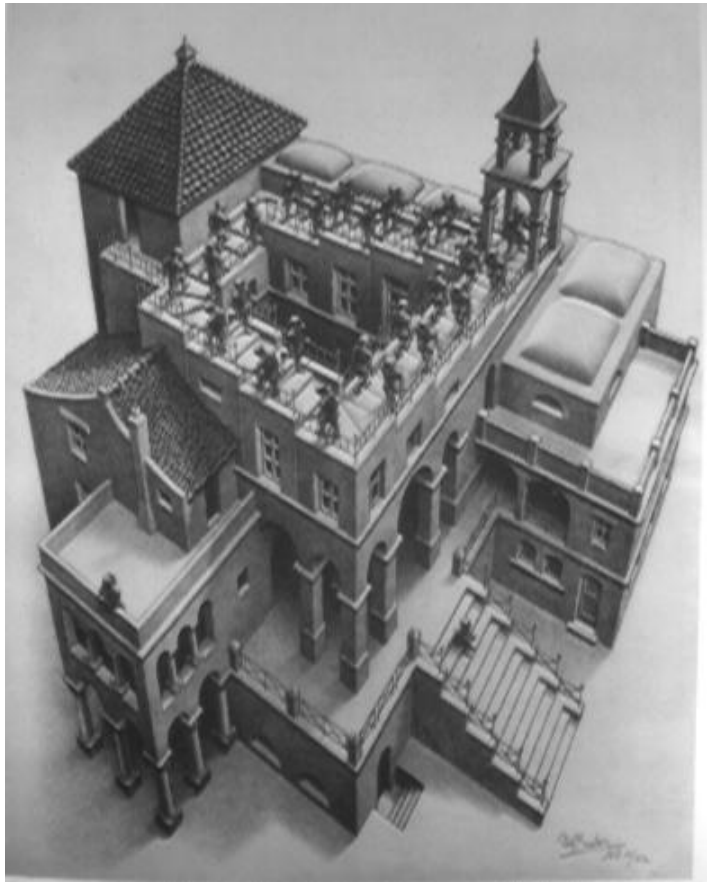


# Ilusiones ópticas

## Biestable

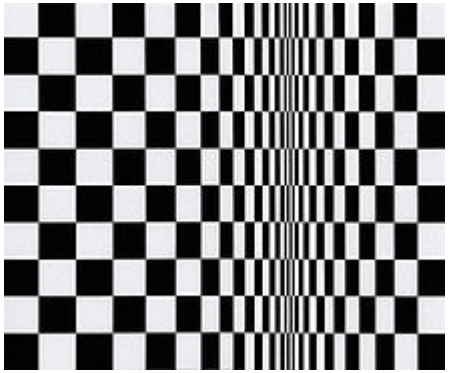
*Spinning dancer* (2003), Nobuyuki Kayahara

# Ilusiones ópticas

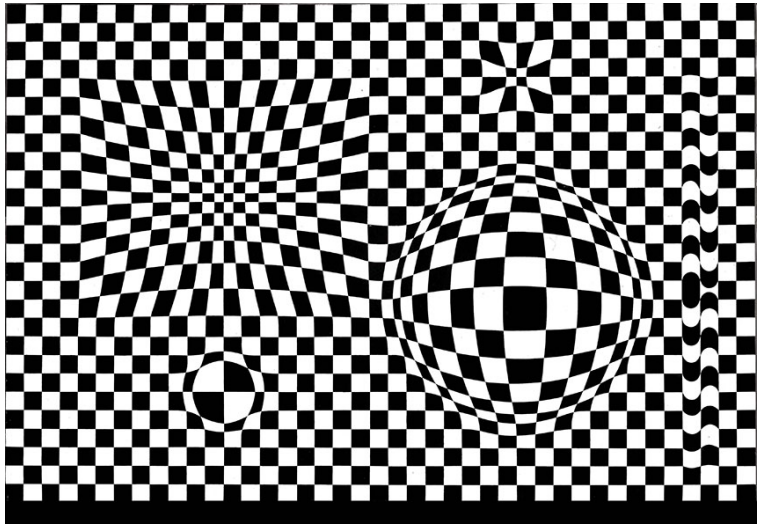


M. C. Escher

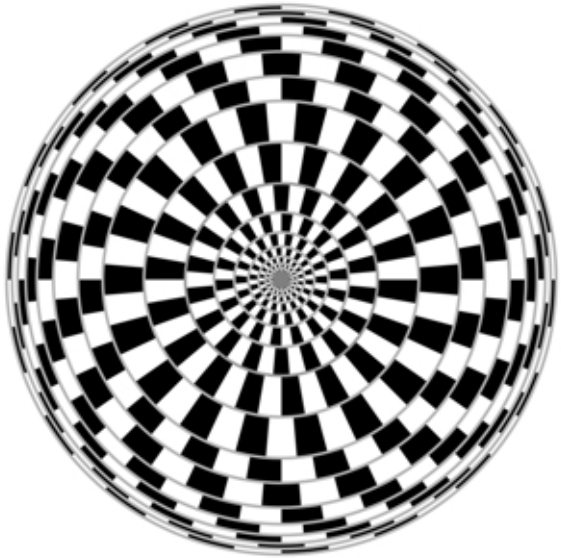
# Op art (optical art)



Movement in Squares, Bridget Riley 1961



Vega, Víctor Vasarely



Uzumaki ampan, Akiyoshi Kitaoka

Percepción

**Ellen DeGeneres**
@EllenDeGeneres · **Seguir**

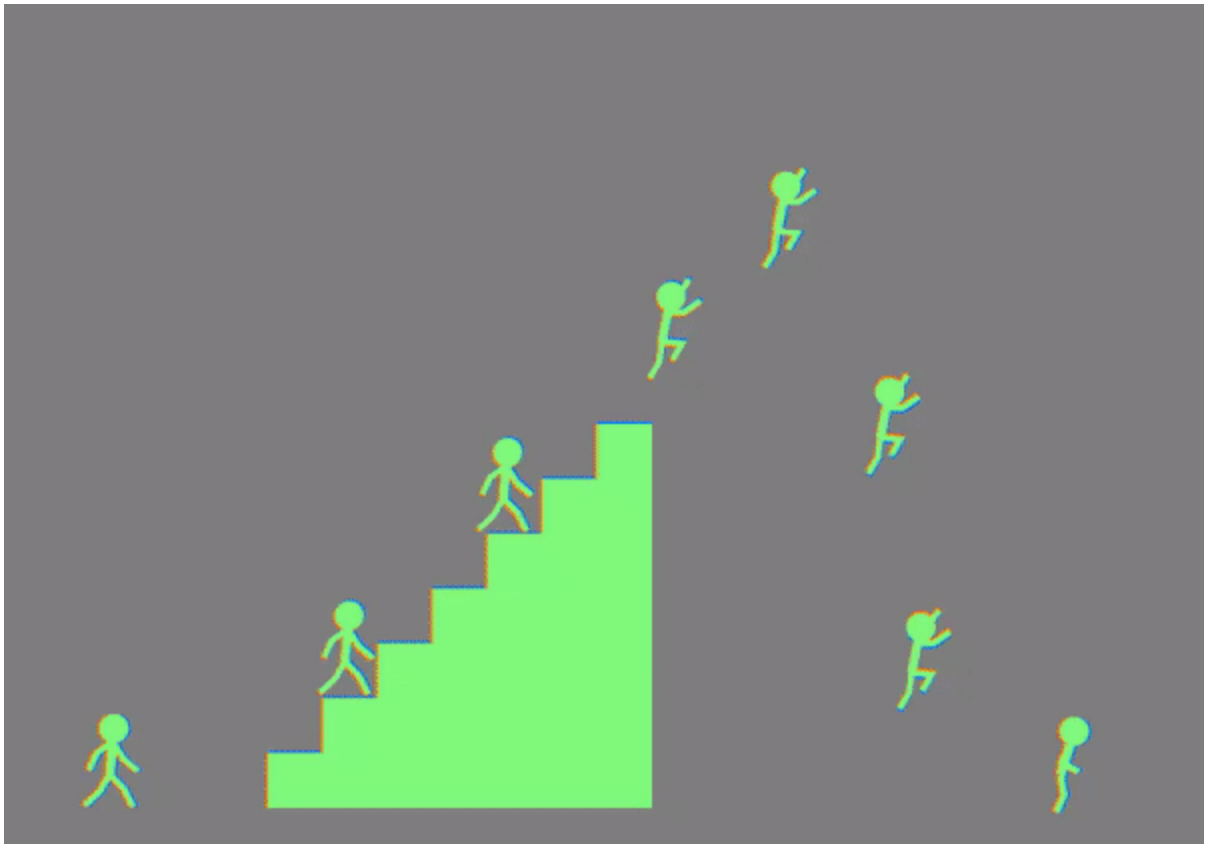
From this day on, the world will be divided into two people. Blue & black, or white & gold. ellen.tv/1vE3oDx

3:04 a. m. · 27 feb. 2015

**47,9 mil** **Responder** **Compartir**

**Leer 3,4 mil respuestas**

# Percepción



@jagarikin

# ¿Conoces alguna ilusión óptica para mostrar al grupo?

# FORO CAMPUS VIRTUAL

# ¿Dónde está presente la Visión por Computador?

## Respuestas 24/25

Varias personas

Alejandro A.

Antonio S.. Mauro

Alejandro R., Joel

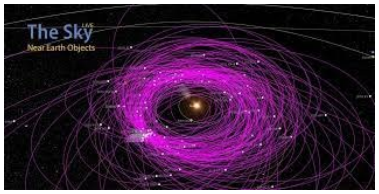
Juan José, Alejandro P.

Alejandro A. y P.

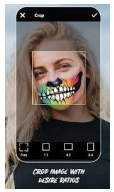
Arhamis

Adrian

Elena N.




Elena N.



Sara

Saúl

Giovanni, Santiago

# ¿Dónde está presente la Visión por Computador?

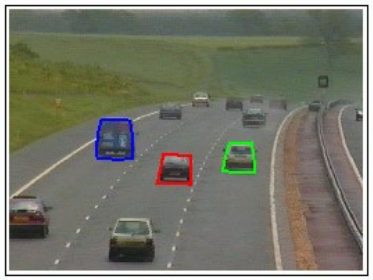
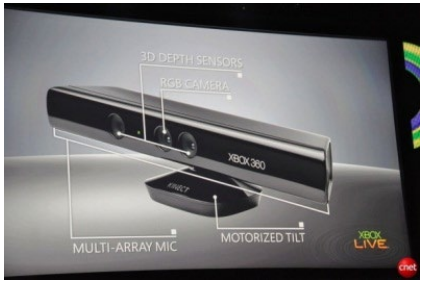
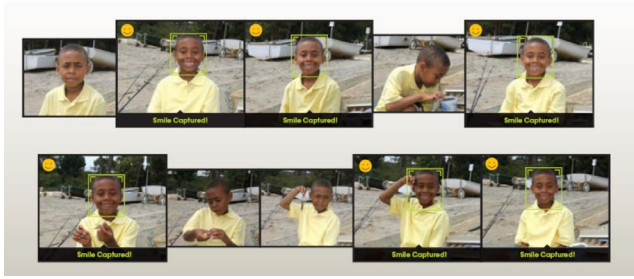
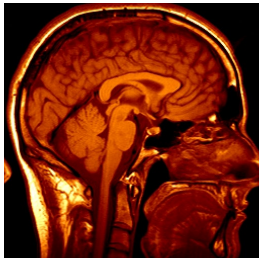


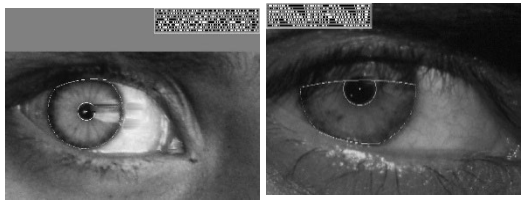
Figure 6: *Sixteen photographs of a church taken at 1-stop increments from .30 sec to —— sec. The sun is directly behind the rightmost stained glass window, making it especially bright. The blue borders seen in some of the image margins are induced by the image registration process.*



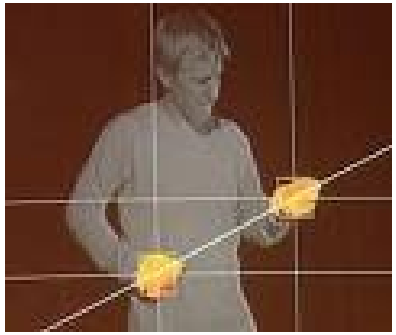





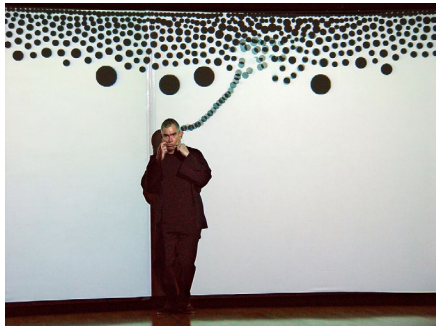
# ¿Dónde está presente la Visión por Computador?



*"How the Afghan Girl was Identified by Her Iris Patterns"* wikipedia



Helsinki U., 2005



*Messa di voce*, G. Levin et al., 2003

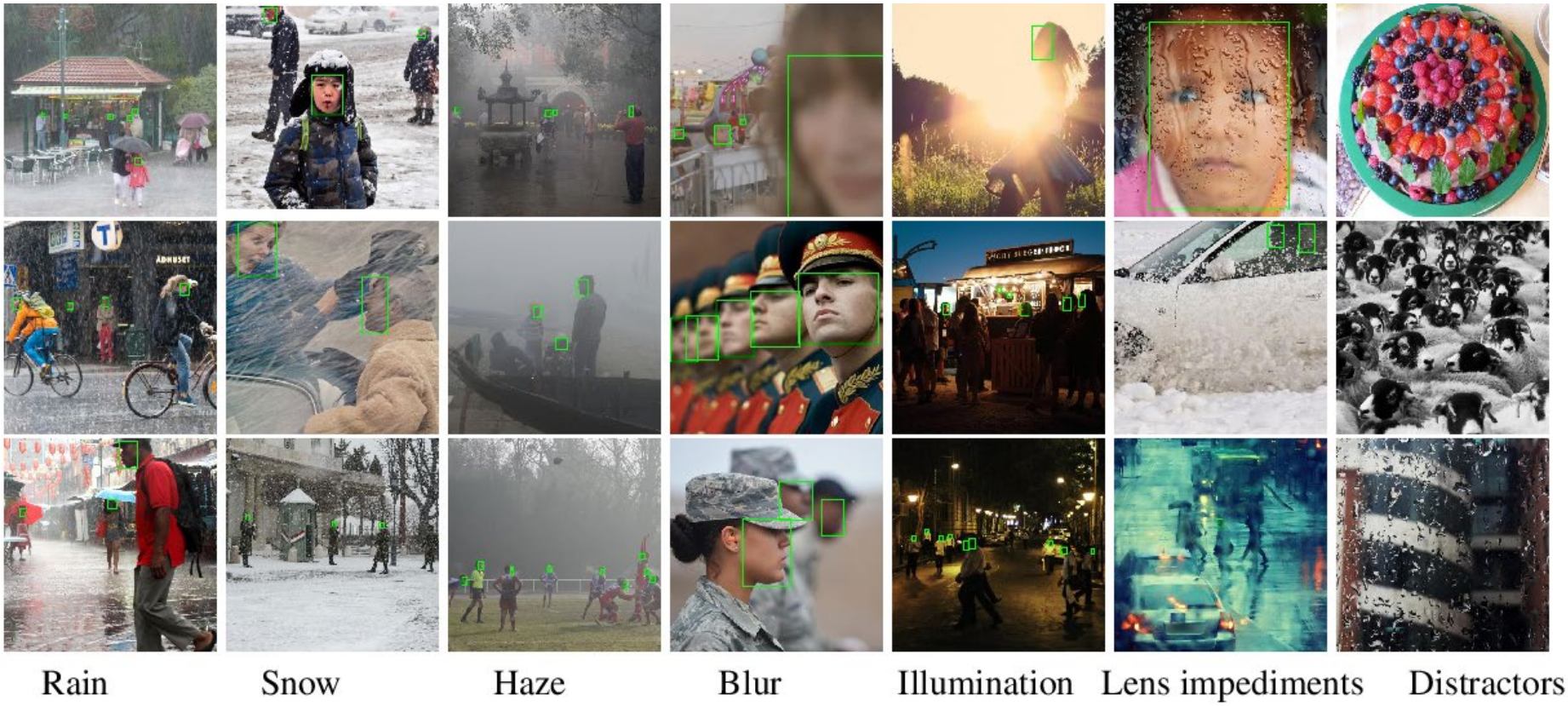
*Logywave*, J. Peña, 2012

# ¿Dónde está presente la Visión por Computador?

Google Lens

# Evaluación

No trivial, p.e. detección de caras



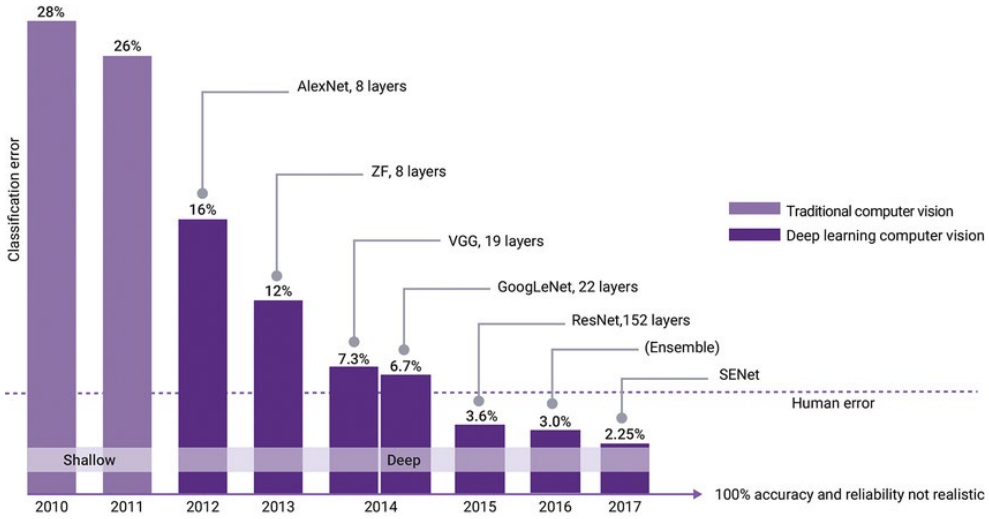

Unconstrained Face Detection Dataset (UFDD)

# Evaluación

Competiciones:

- Pascal VOC
- ImageNet Large Scale Visual Recognition (ILSVRC)
- Kaggle

1.000 clases
1.431.167 imágenes

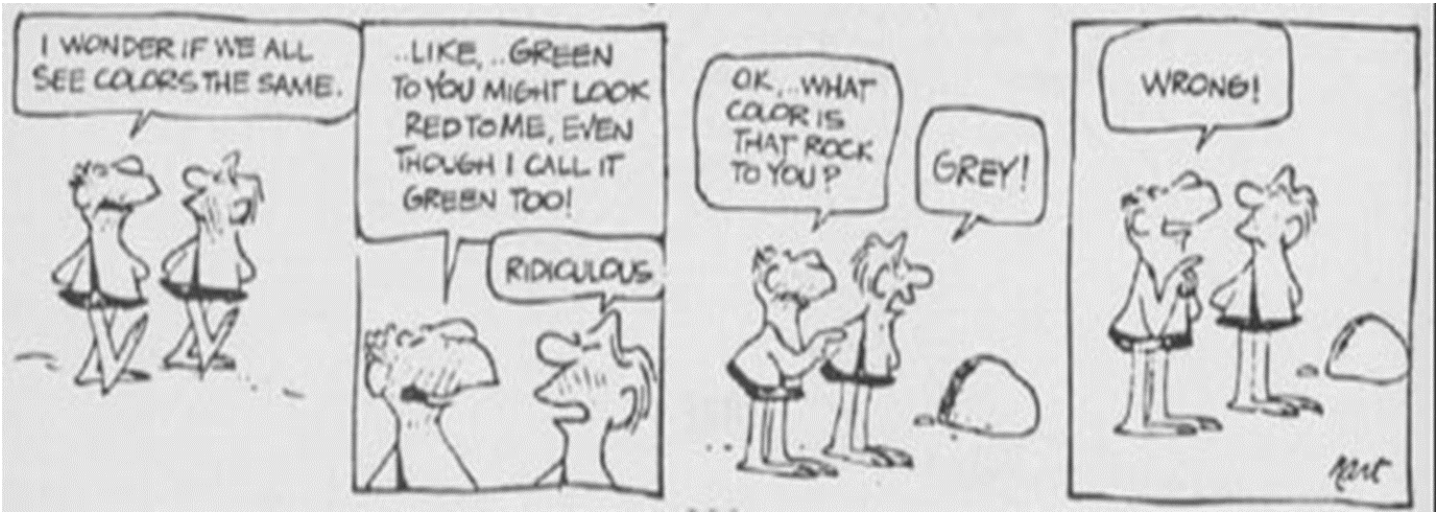



ILSVRC

Papers With Code

# Bibliografía


- V. Bruce and A. Young, *The eye of the beholder*, Oxford University Press
- F. Durand, *The Art and Science of Depiction*, MIT LCS Graphics Group Gombrich, Art and Illusion.
- R. Szeliski. *Computer Vision: Algorithms and Applications*, 2nd ed. 2022


Johnny Hart