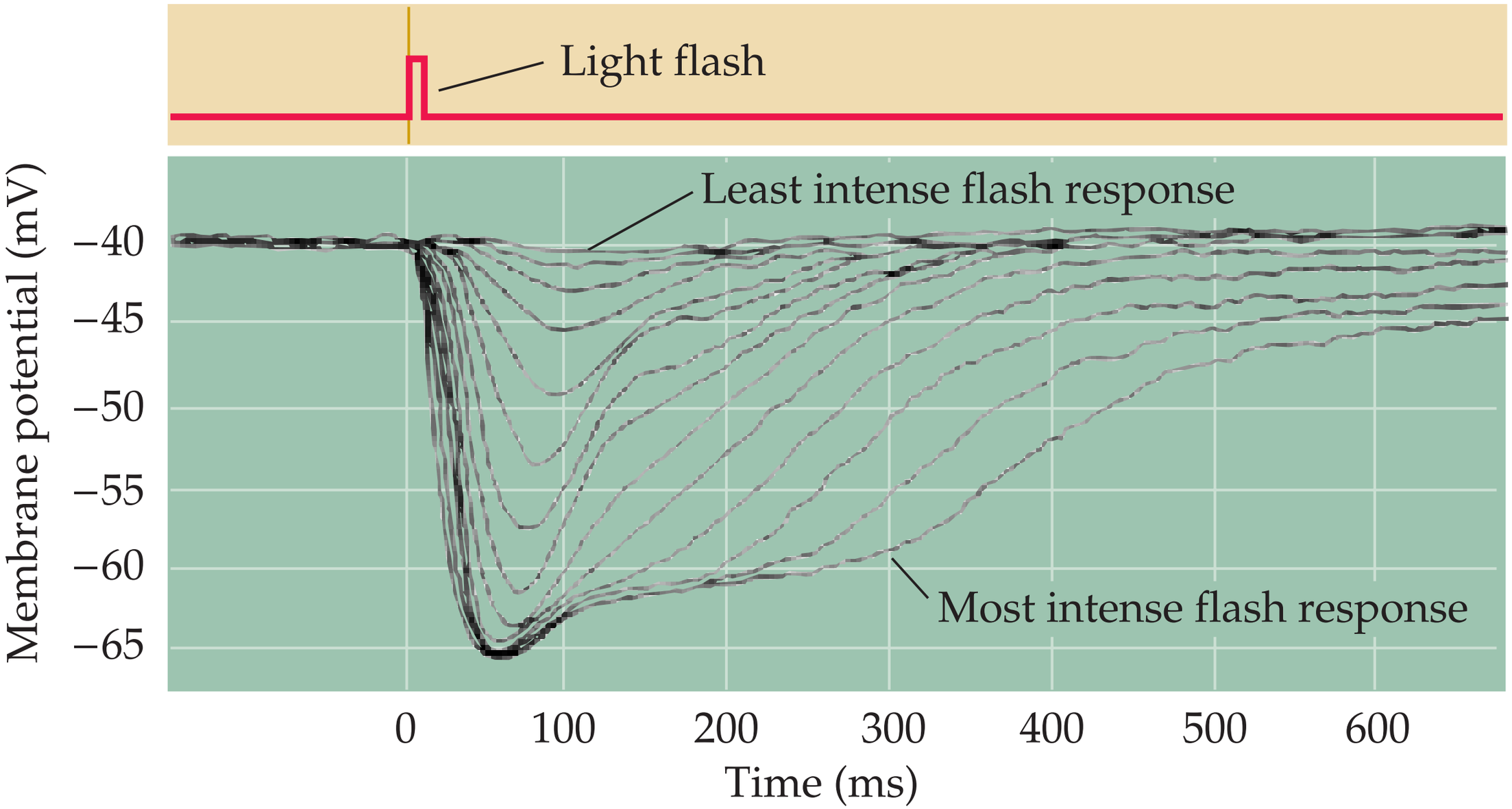
Percezione e Psicofisica

a.a. 2021/2022

Nicola Bruno

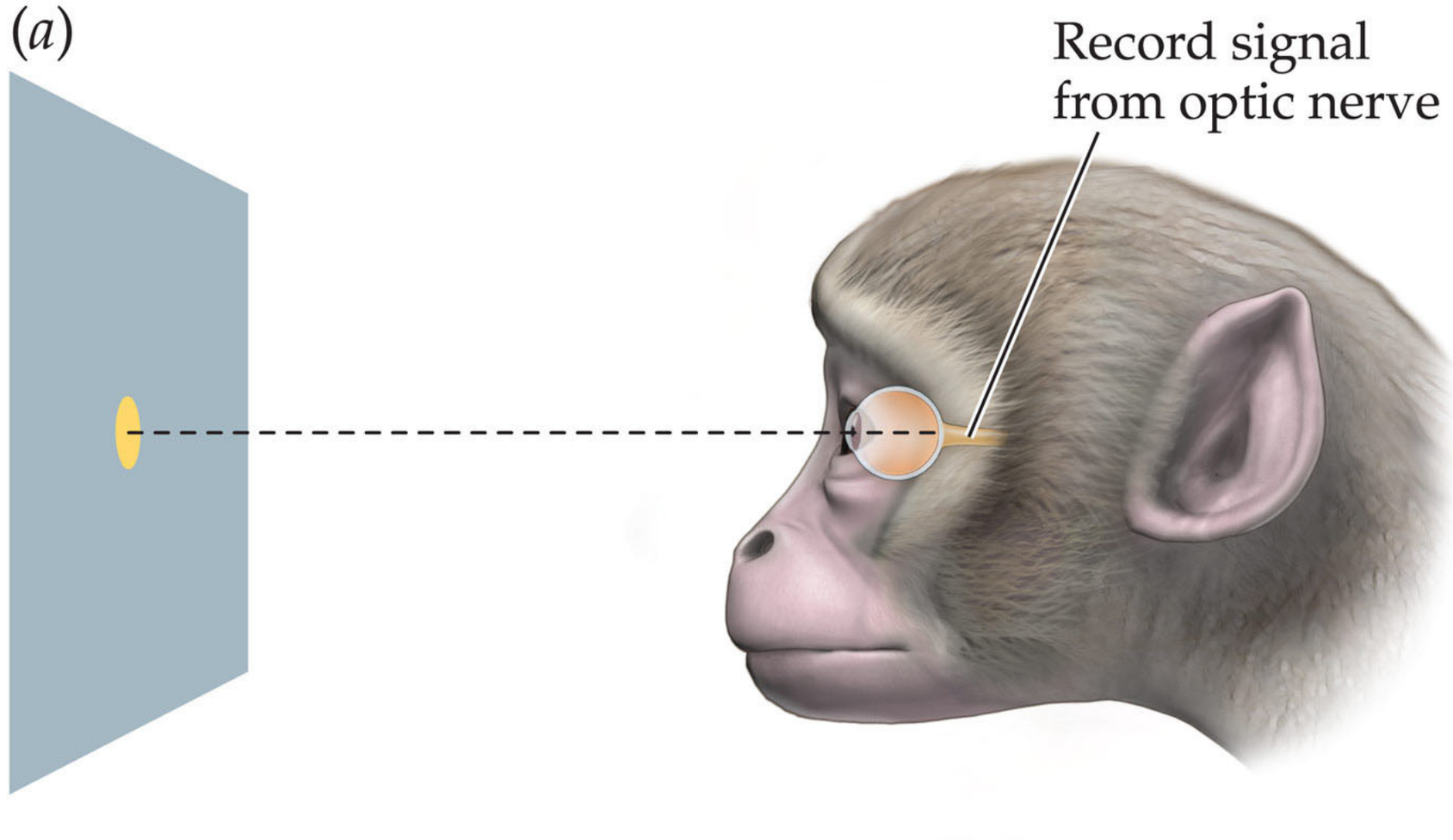
Lezione 17-19

visione di basso livello: il contrasto



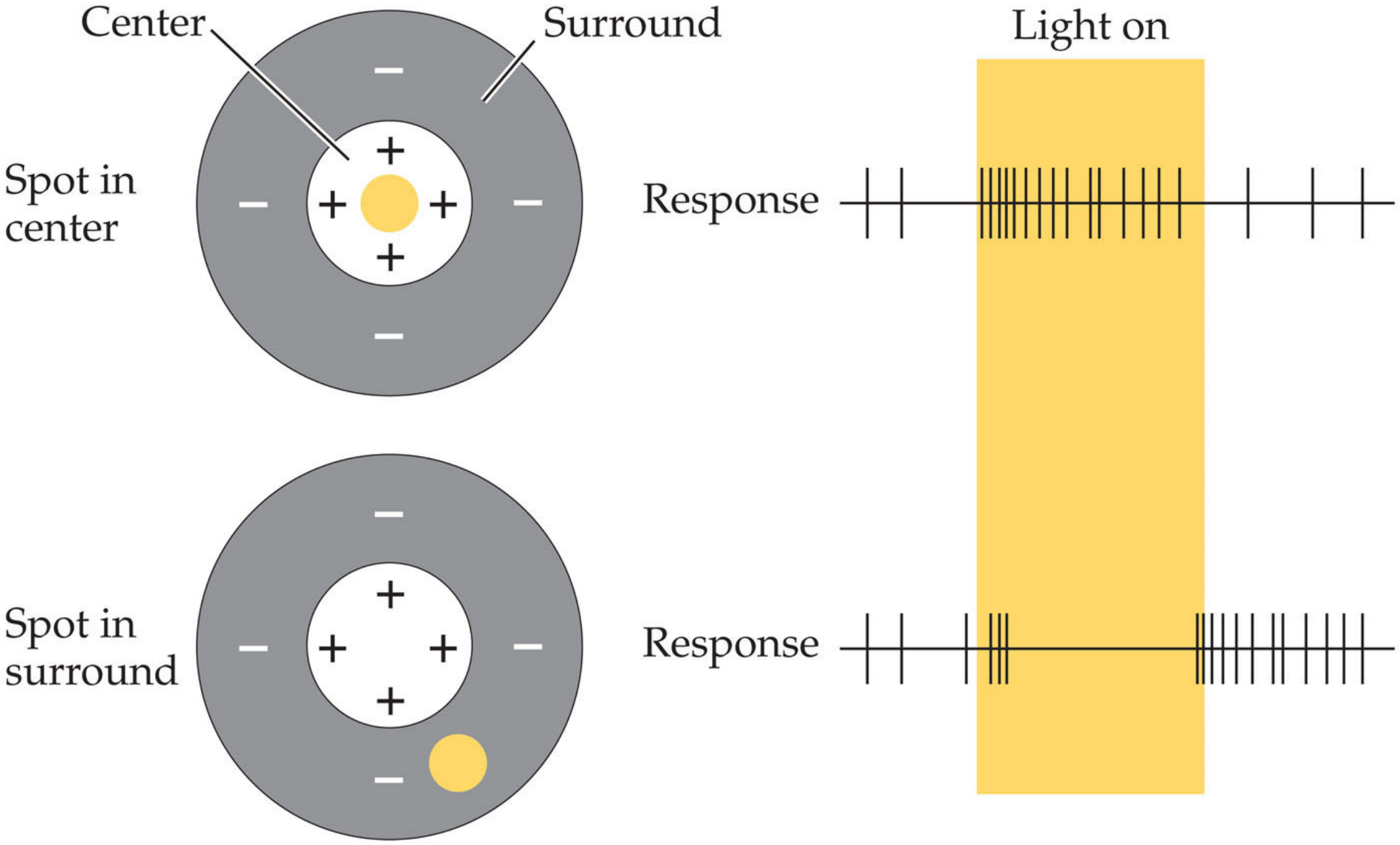
intracellular recording from a single cone of the turtle retina after stimulation with single flashes of varying intensity

RF of ganglion cell



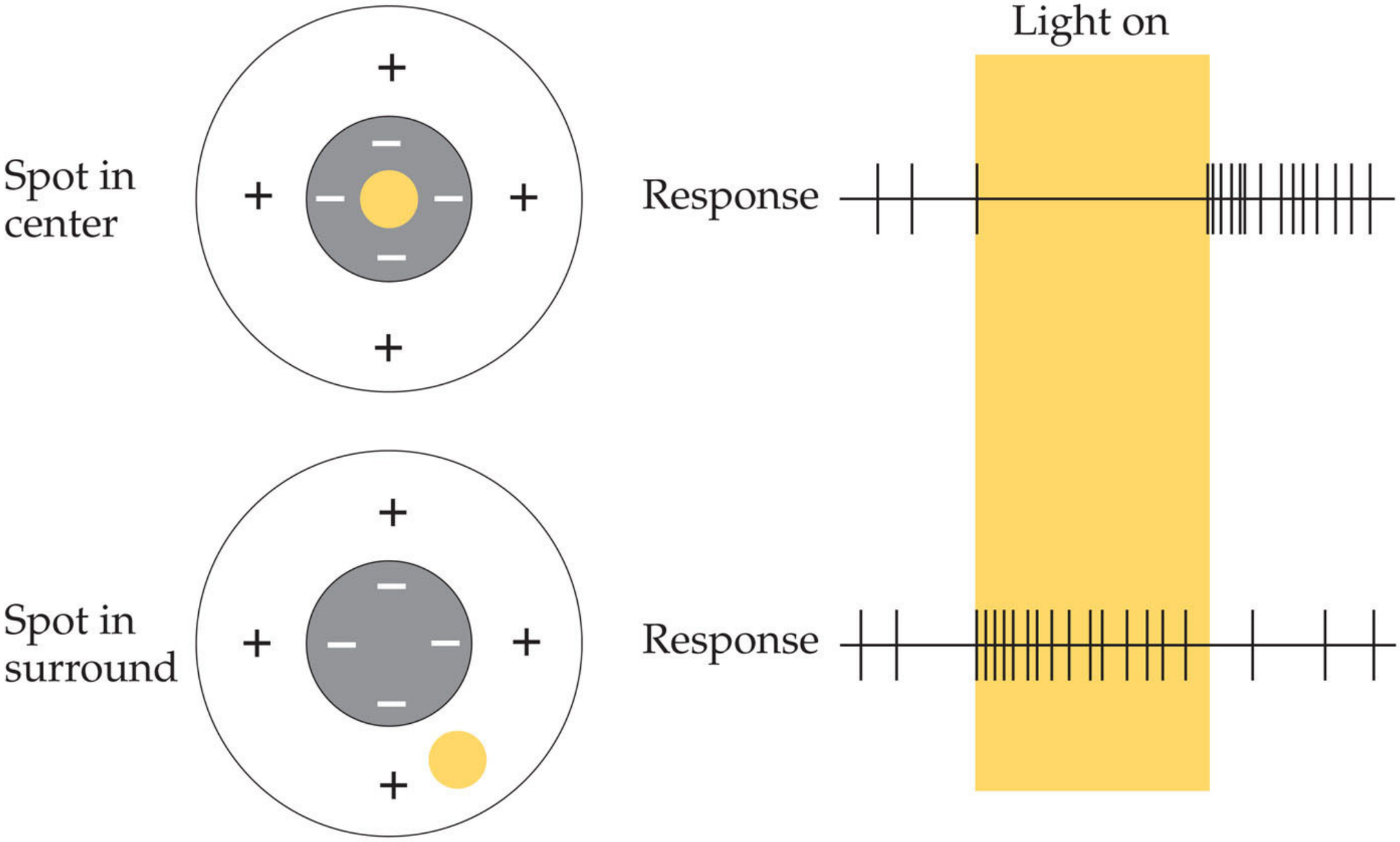
***SENSATION & PERCEPTION 4e,* Figure 2.14 (Part 1)**

(*b*) ON-center ganglion cell



***SENSATION & PERCEPTION 4e,* Figure 2.14 (Part 2)**

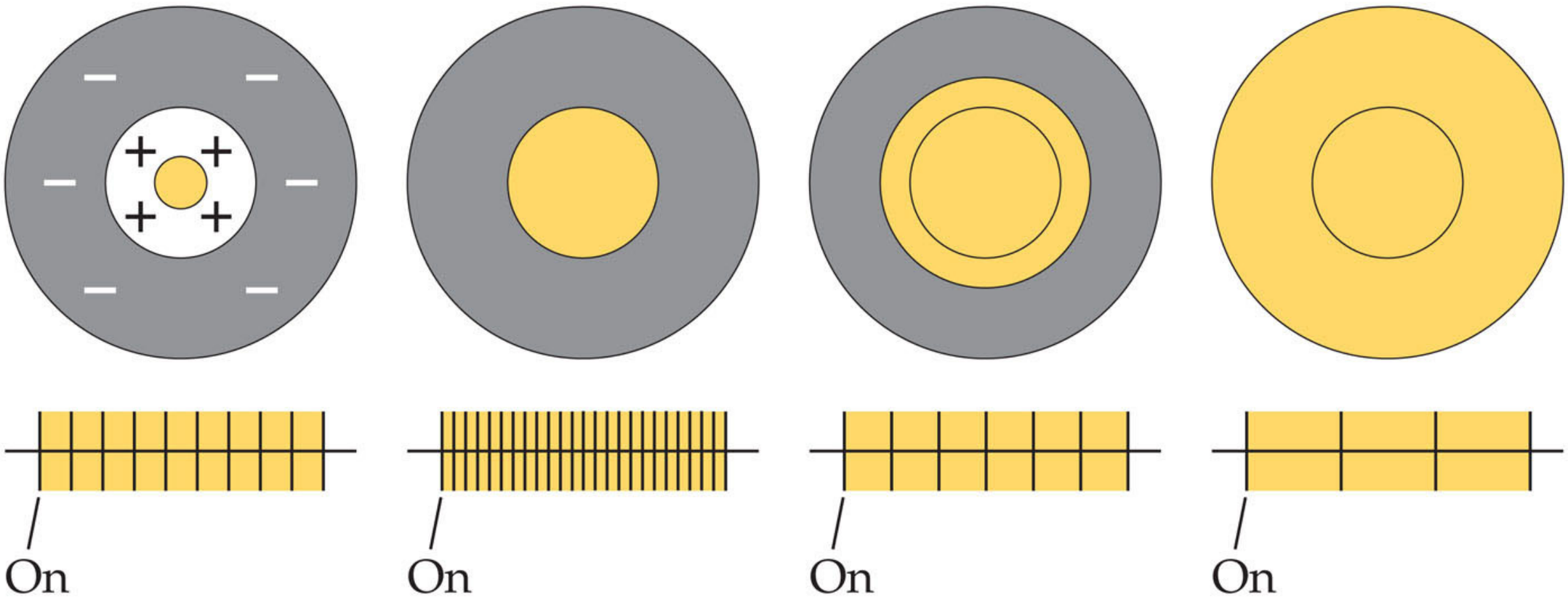
(*c*) OFF-center ganglion cell



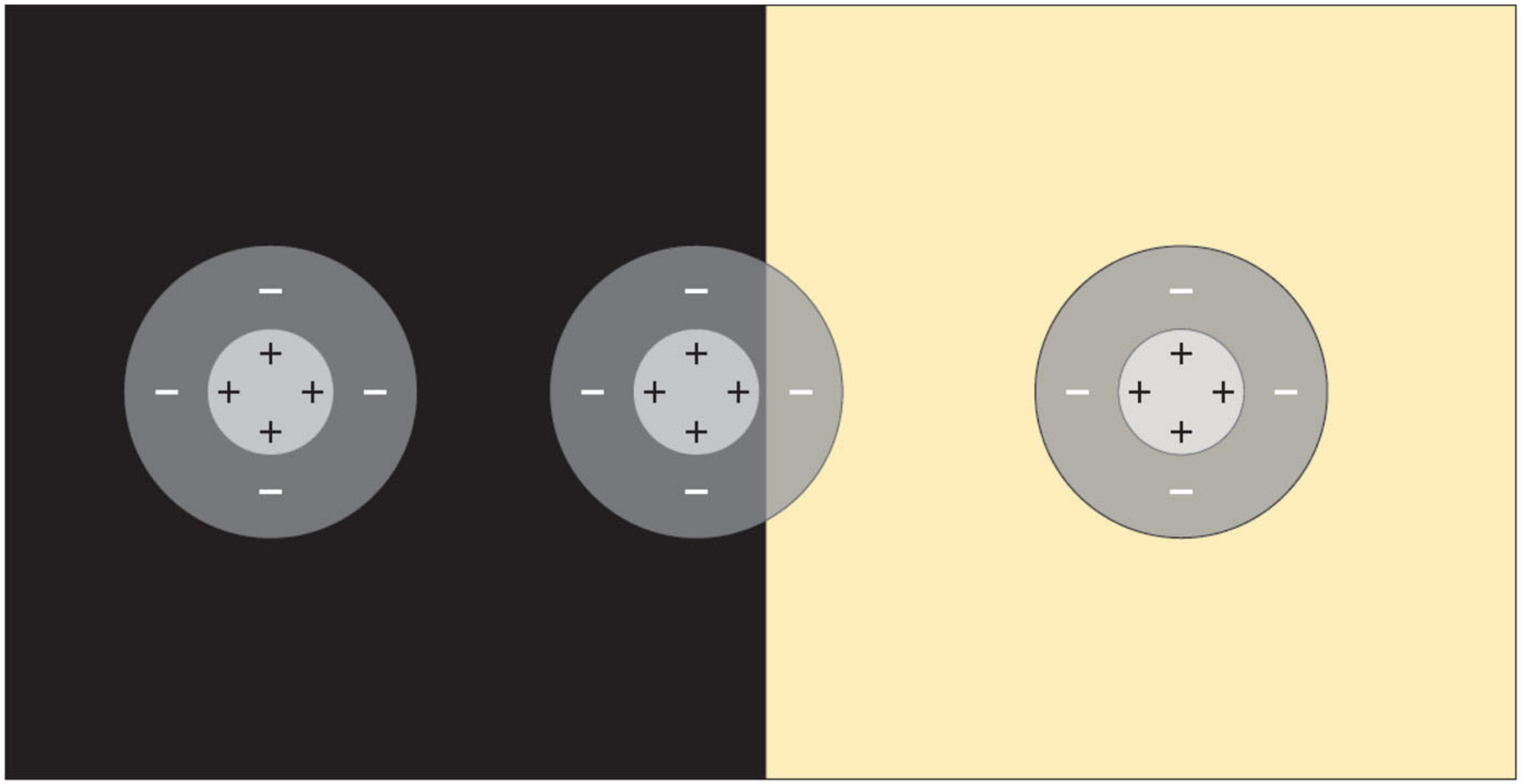
***SENSATION & PERCEPTION 4e,* Figure 2.14 (Part 3)**

= spot size

(*d*)

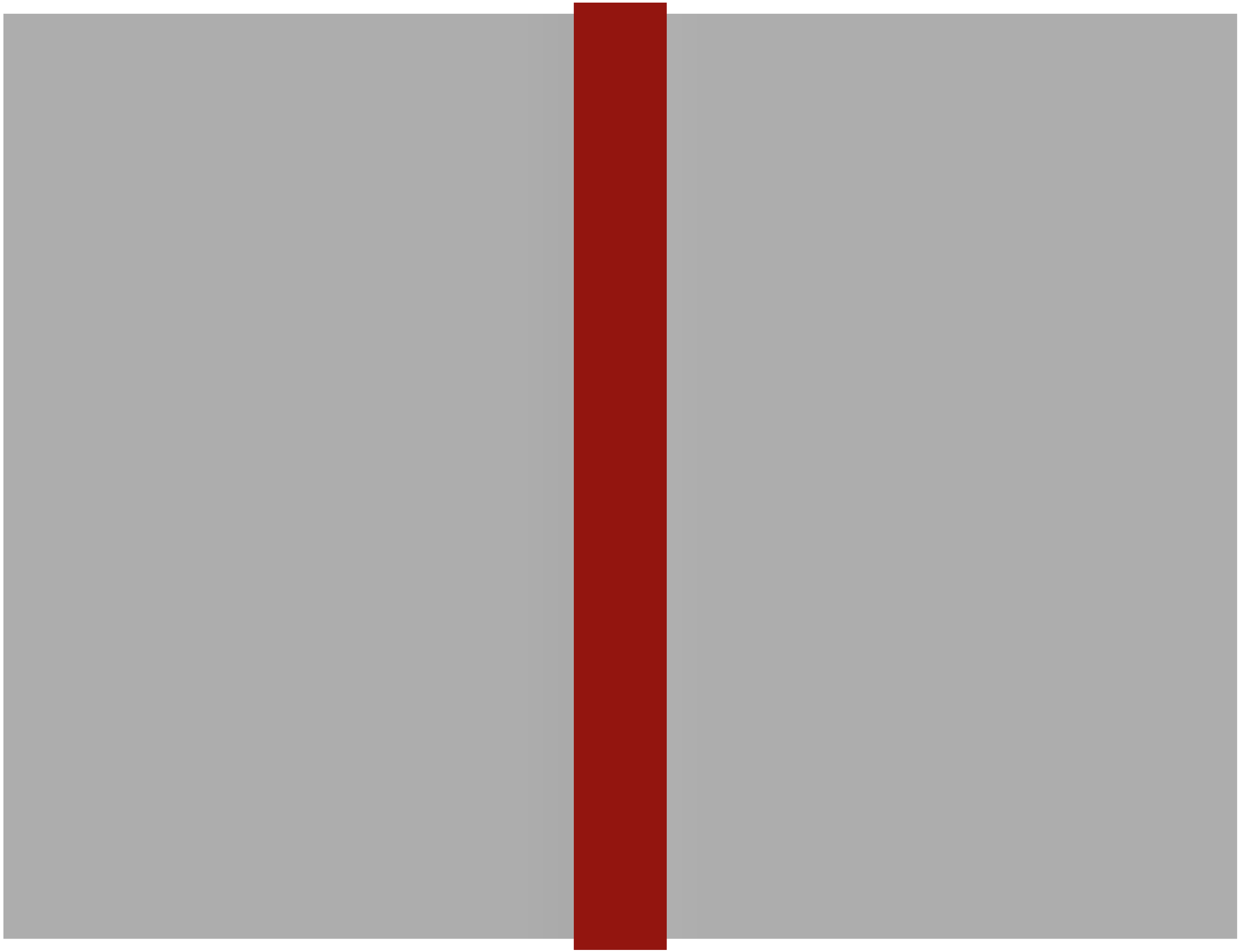


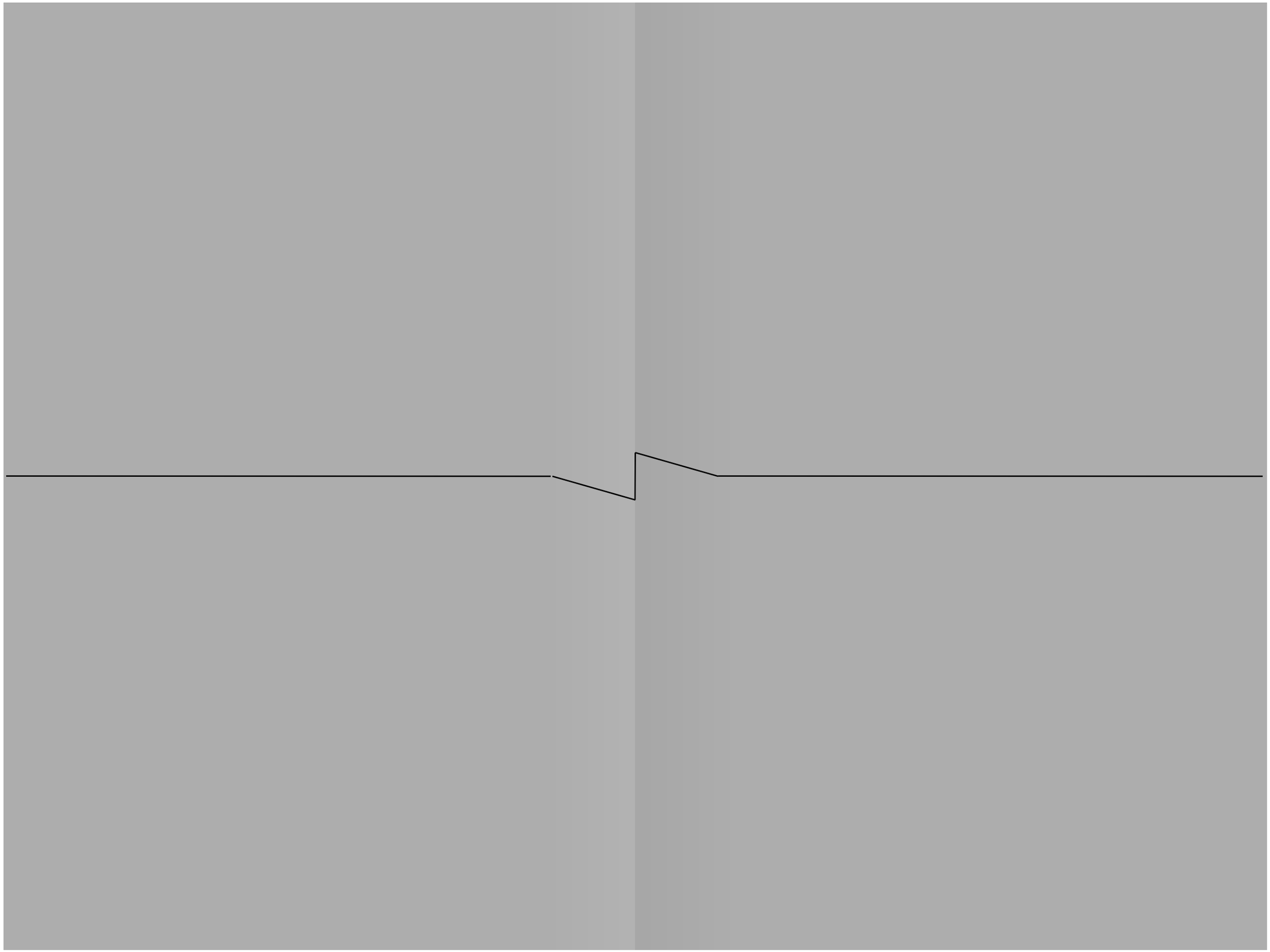
***SENSATION & PERCEPTION 4e,* Figure 2.14 (Part 4)**



***SENSATION & PERCEPTION 4e,* Figure 2.15**

effetto Craik-O’Brien





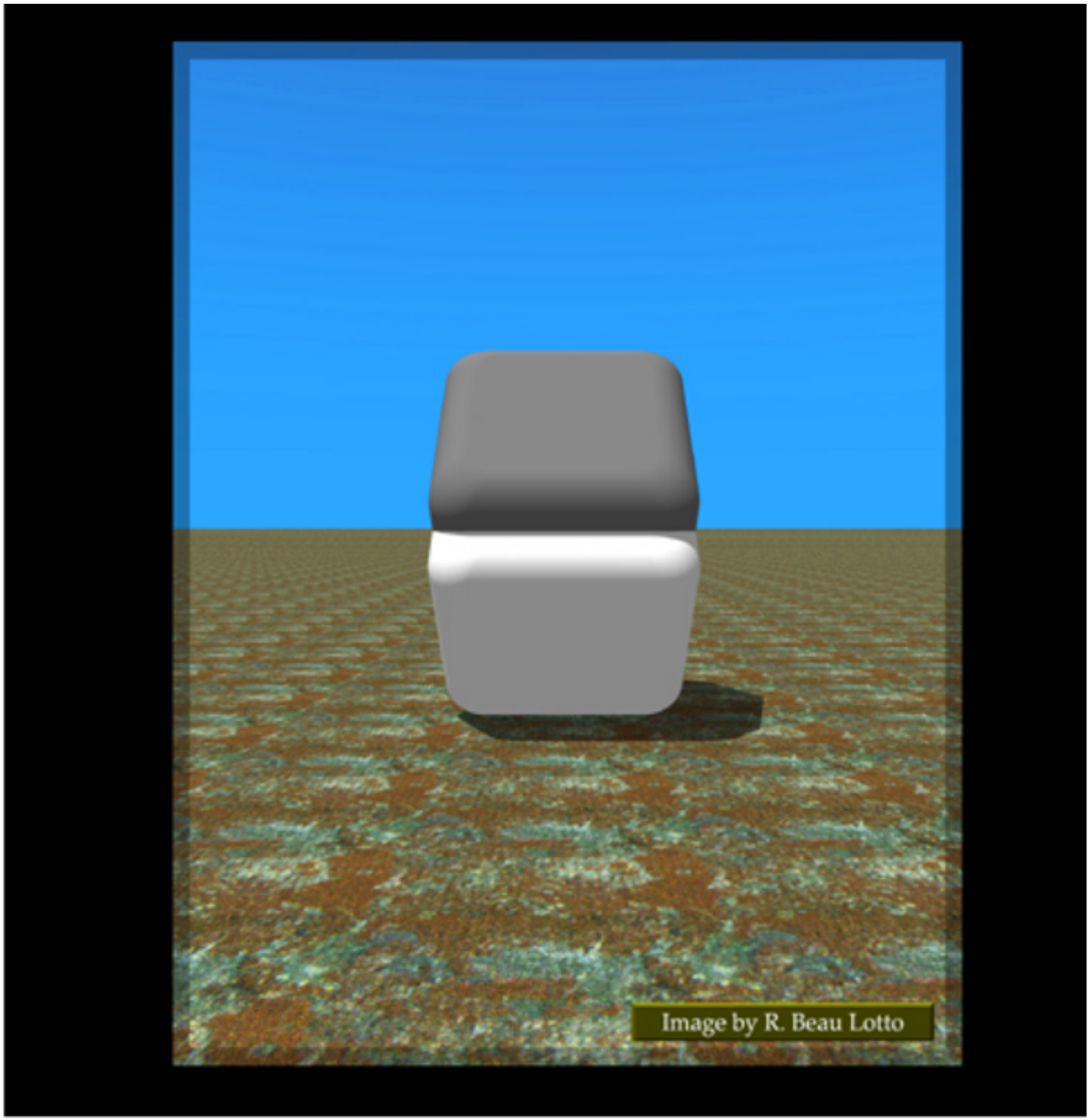
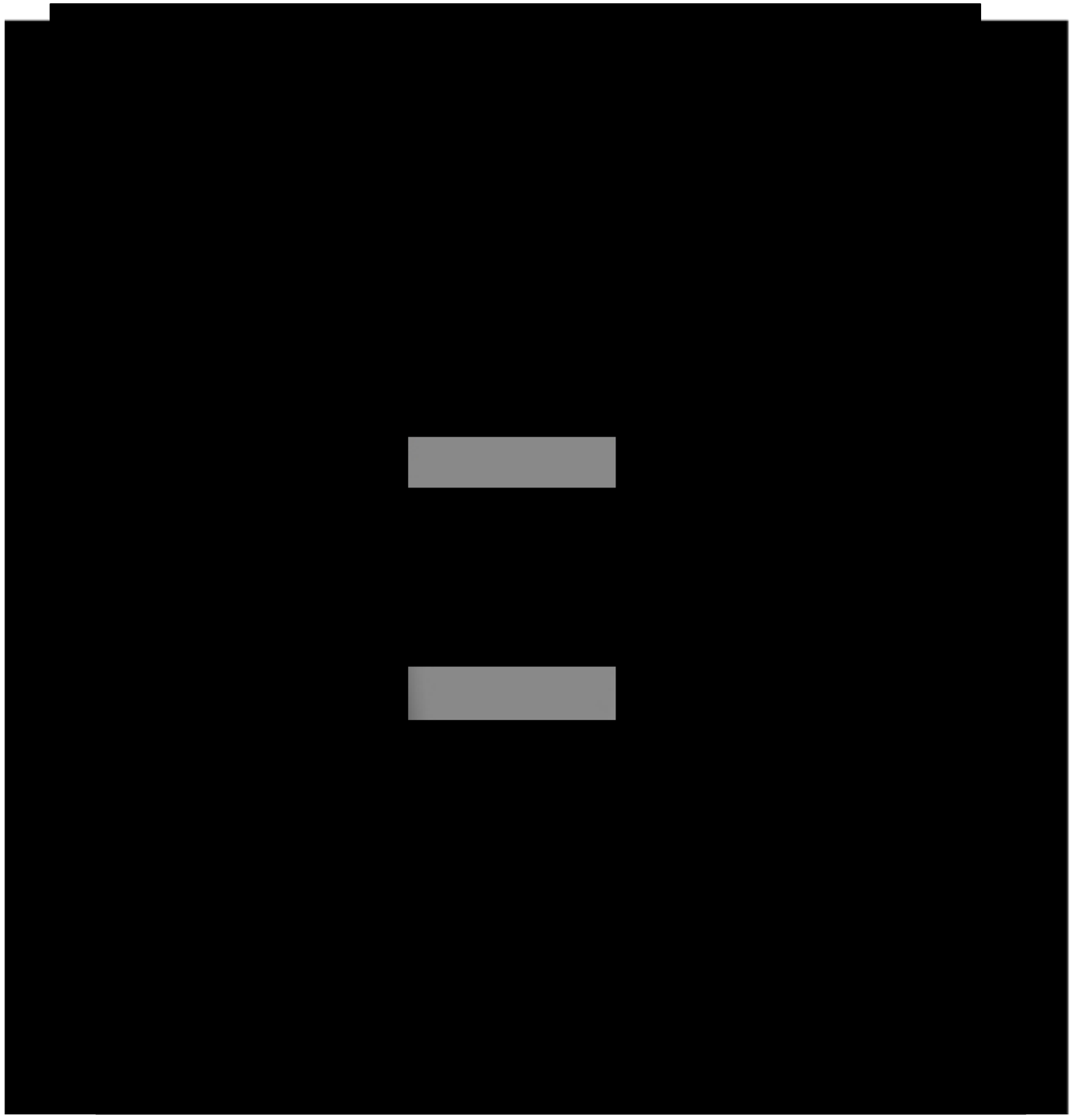
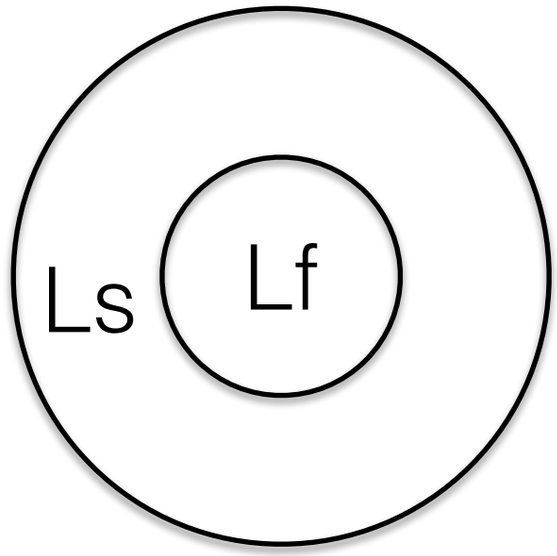


Image by R. Beau Lotto



misurare il contrasto: Weber

$$C = \frac{Lf - Ls}{Ls}$$

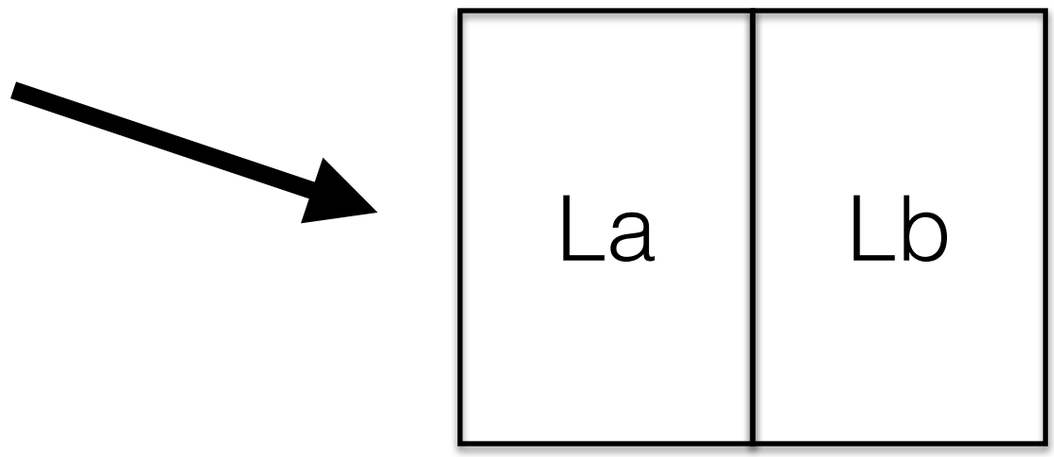


$$\frac{\triangle L}{L}$$

$$\frac{Lf}{Ls}$$

misurare il contrasto: MIchelson

max (La, Lb)
min(La, Lb)

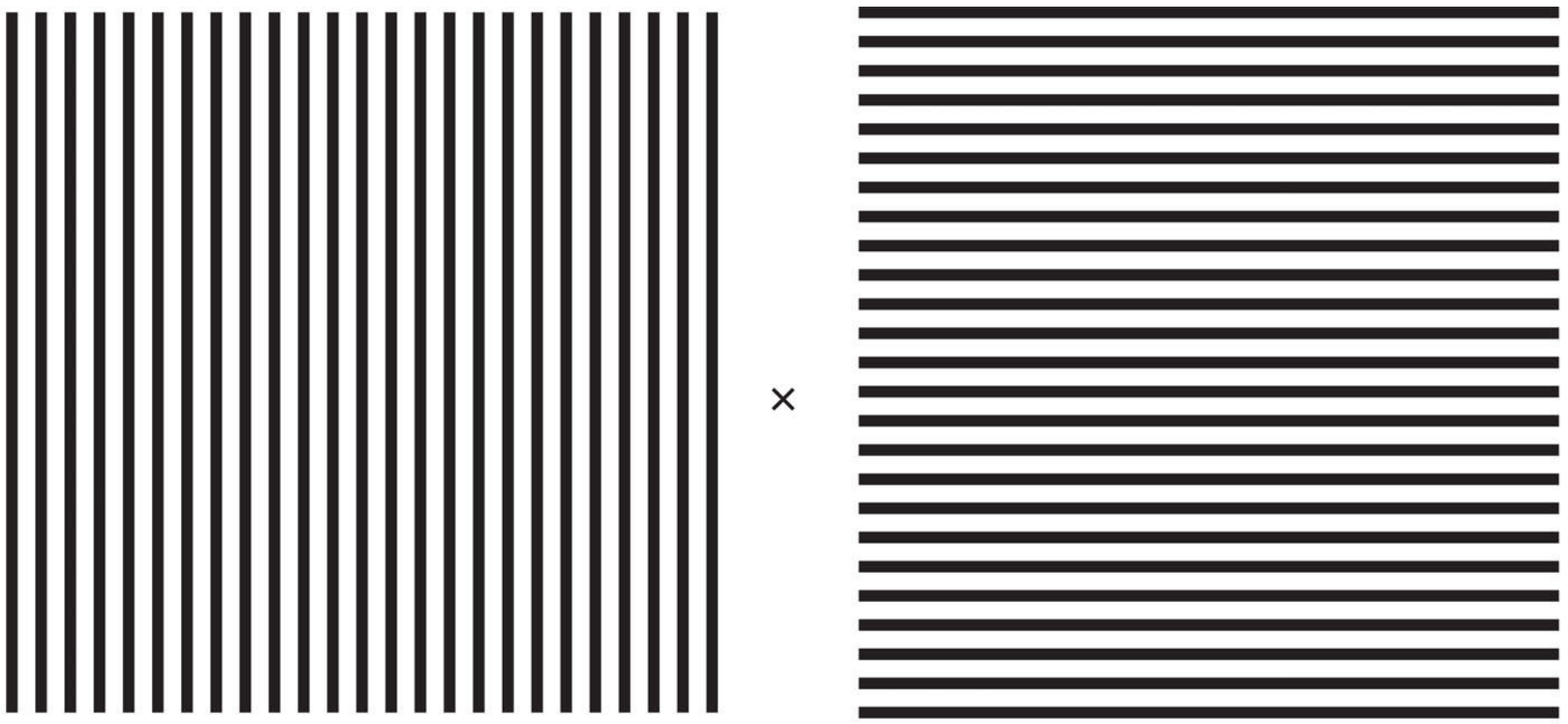


$$C = \frac{Lmax - Lmin}{Lmax + Lmin}$$

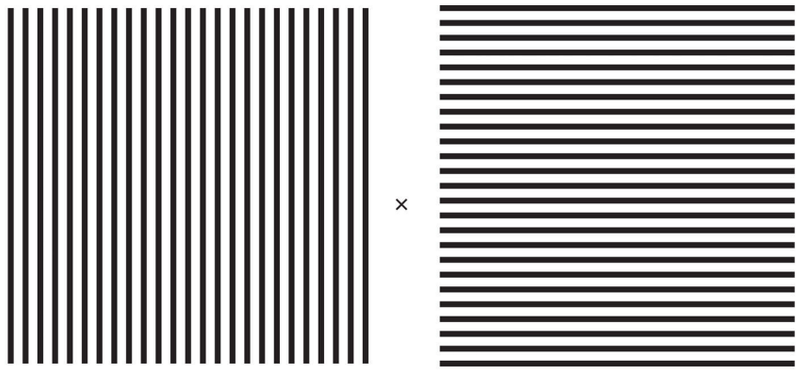
Lezione 20-21

visione di basso livello: contrasto e frequenza spaziale

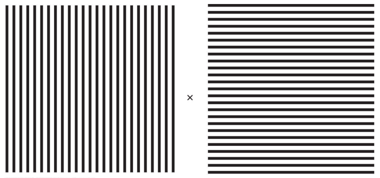
measuring acuity: step back until the two images look the same



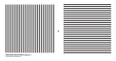
***SENSATION & PERCEPTION 4e,* Figure 3.2**



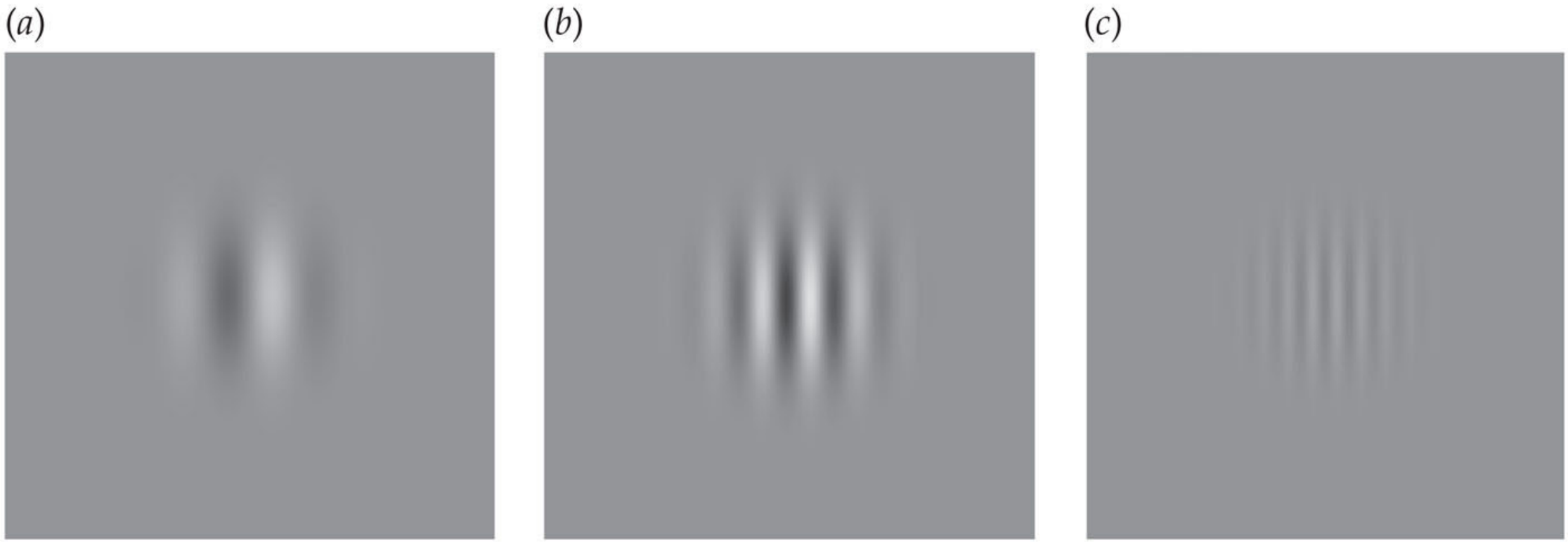
***SENSATION & PERCEPTION 4e,* Figure 3.2**



***SENSATION & PERCEPTION 4e*, Figure 3.2**



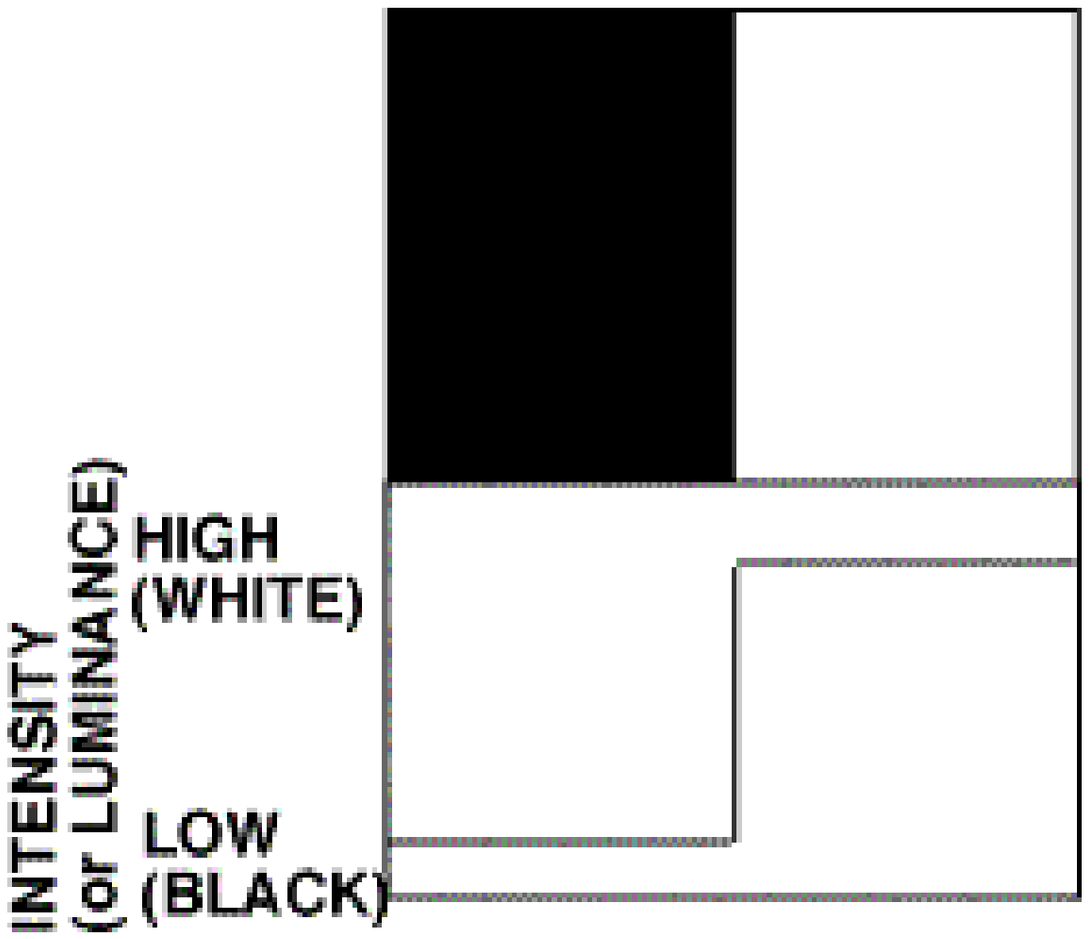
three **gratings** (Gabor patches)



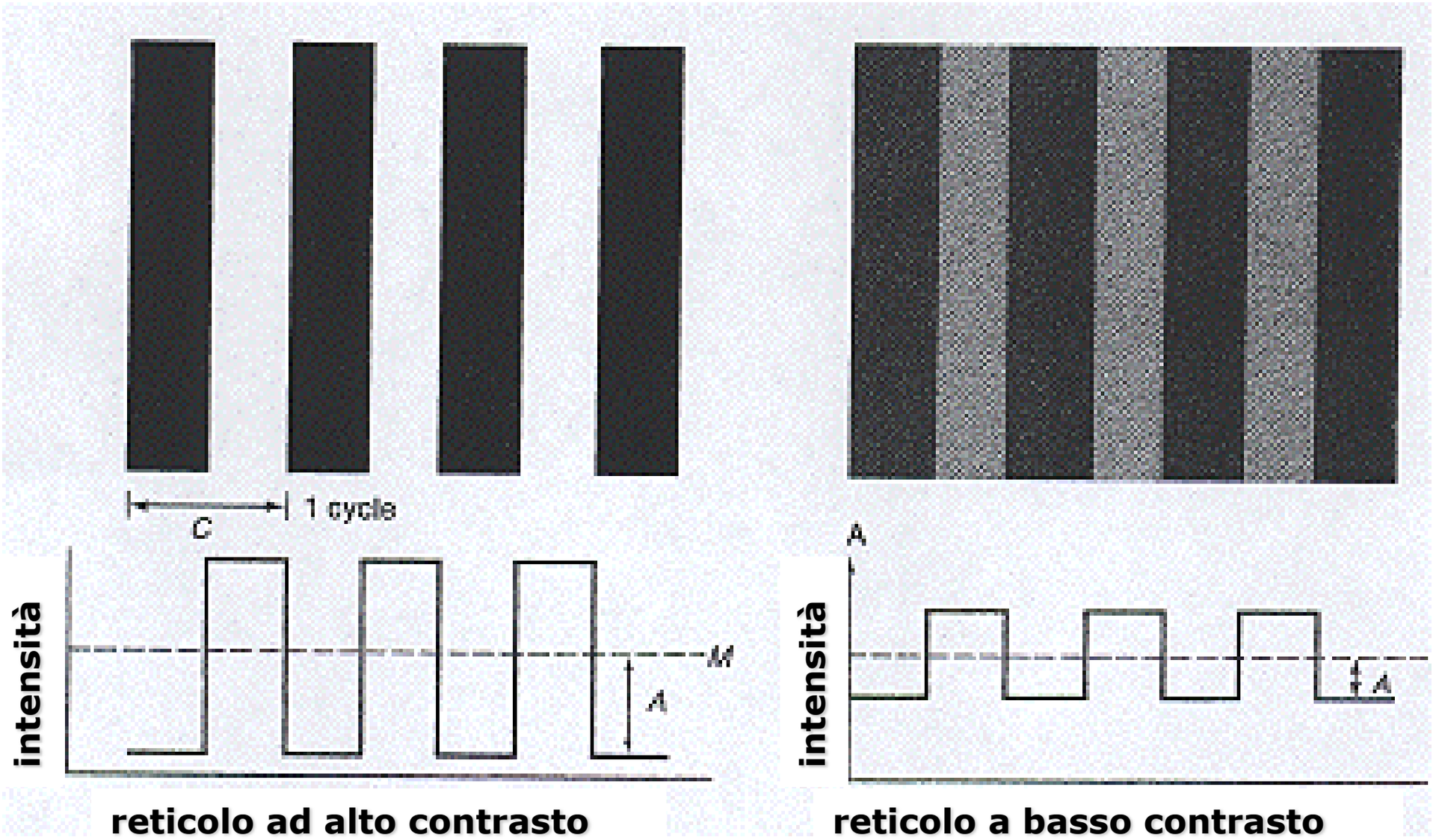
***SENSATION & PERCEPTION 4e*, Figure 3.6**

having **equal contrast** but
different **spatial frequency**

profilo di luminanza



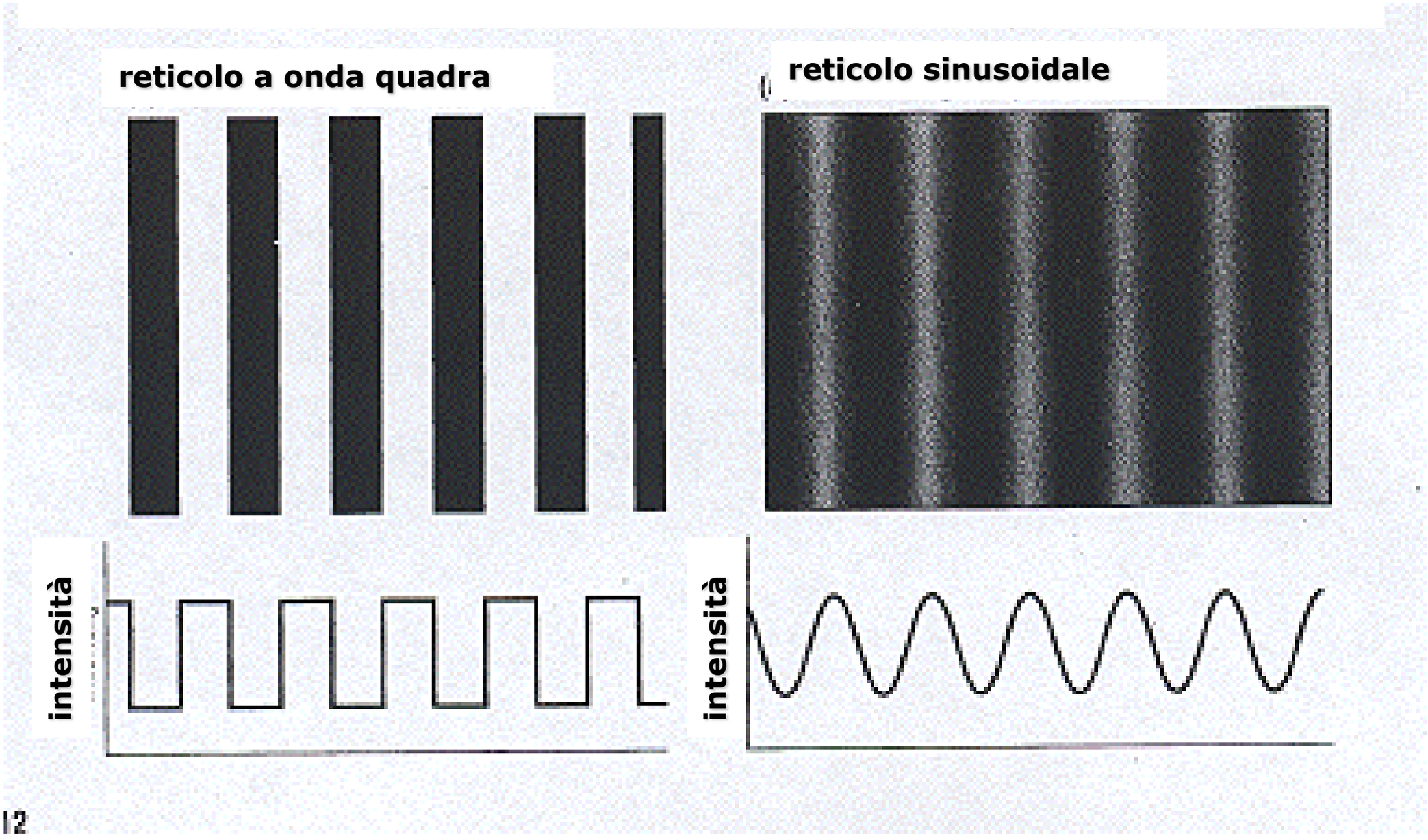
reticoli a diverso contrasto



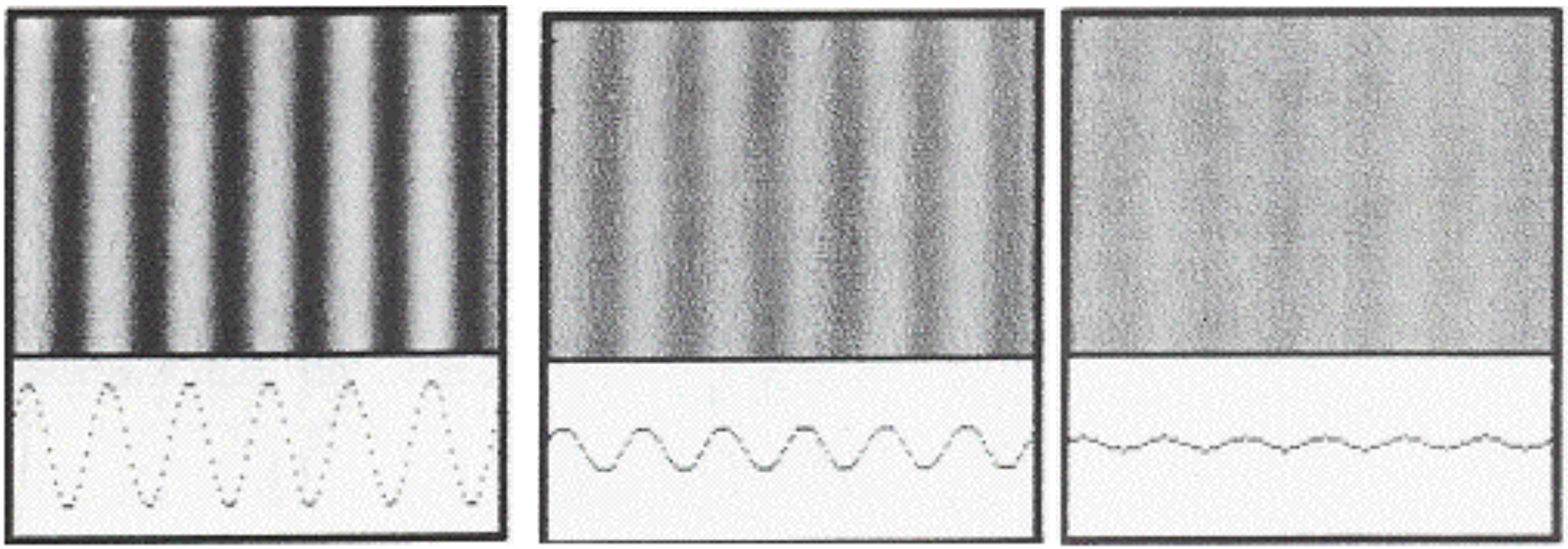
reticolo ad alto contrasto

reticolo a basso contrasto

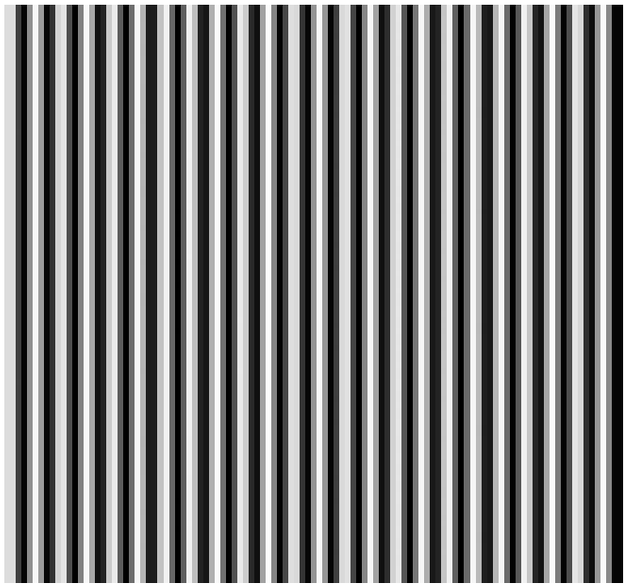
reticoli con diversa variazione di luminanza rispetto allo spazio

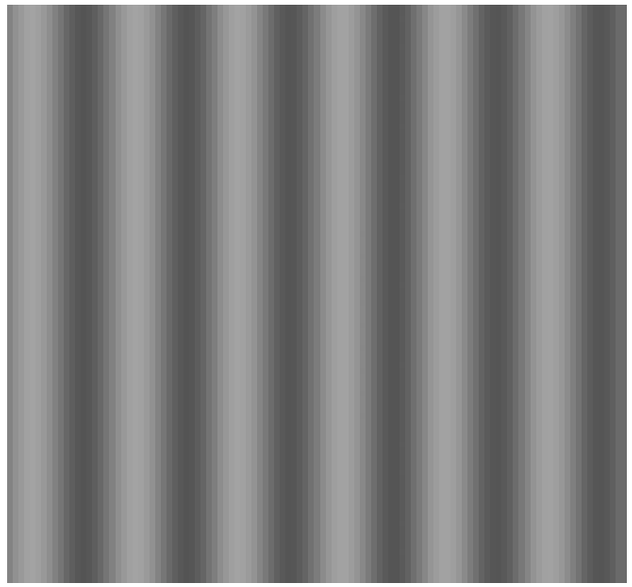


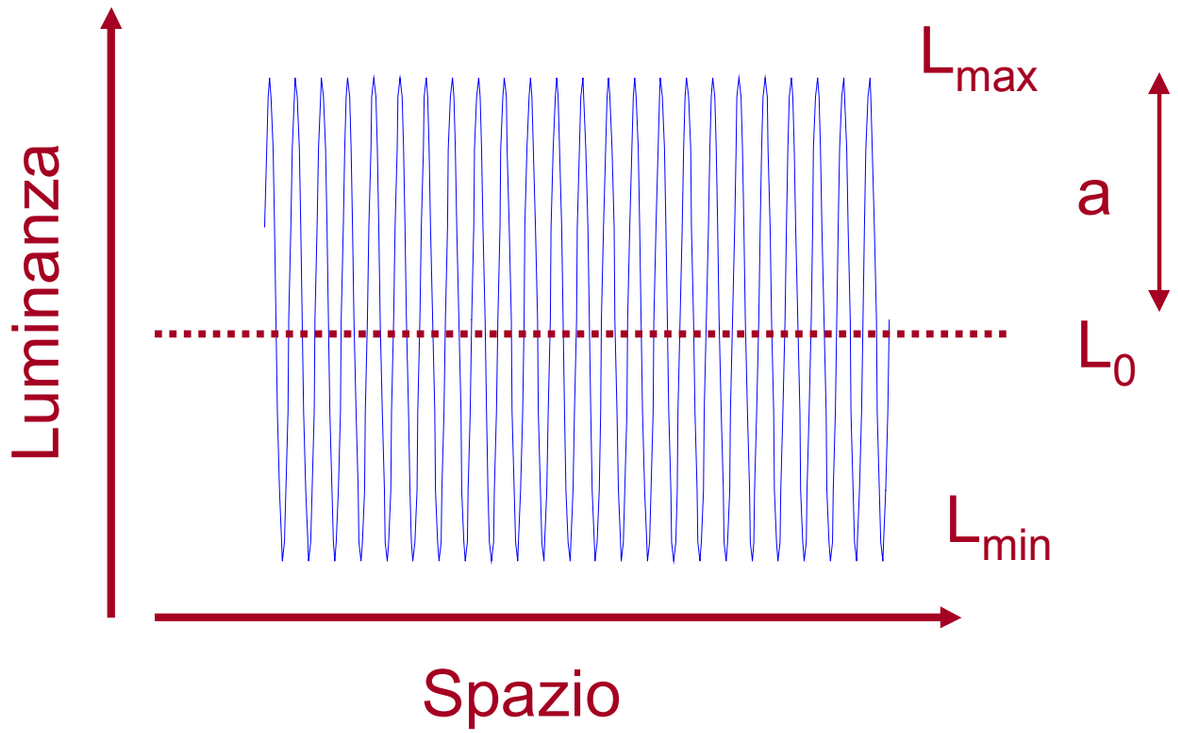
reticoli sinusoidali con diverso contrasto

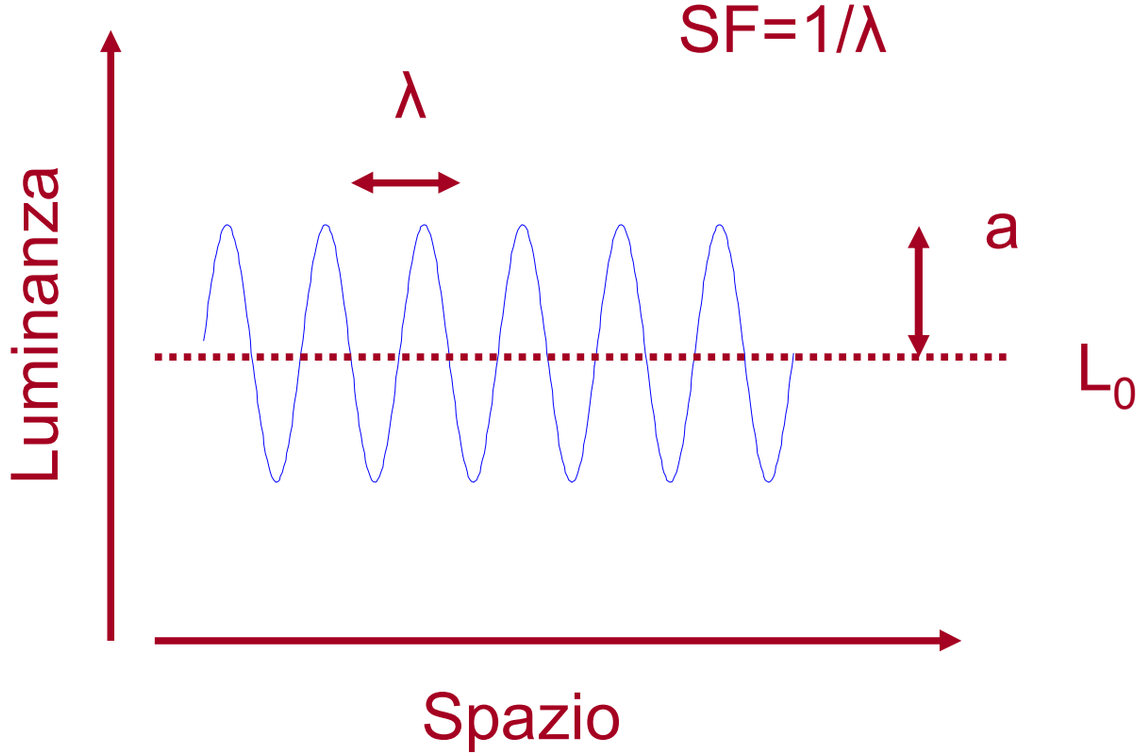


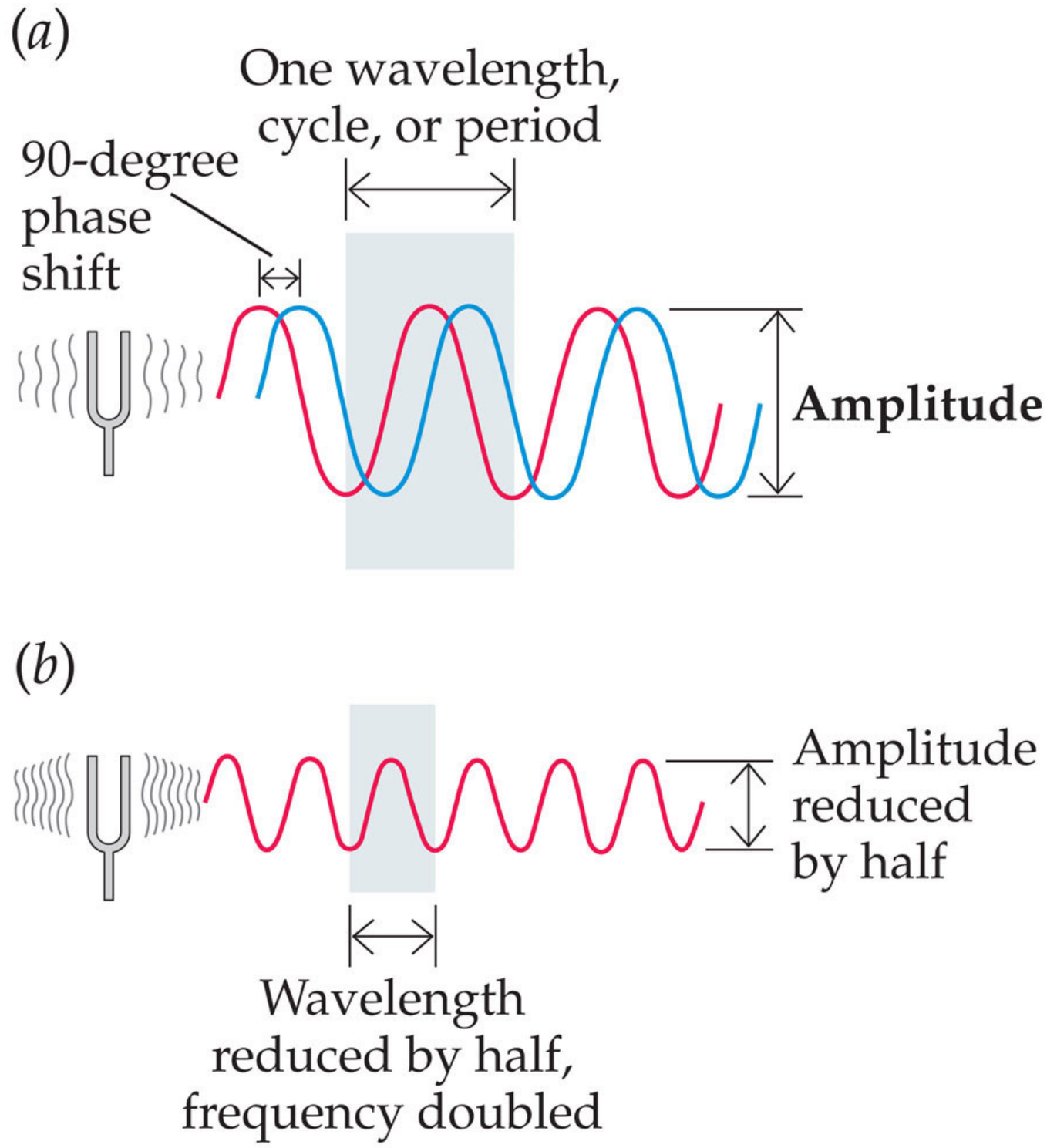
alto **medio** **basso**





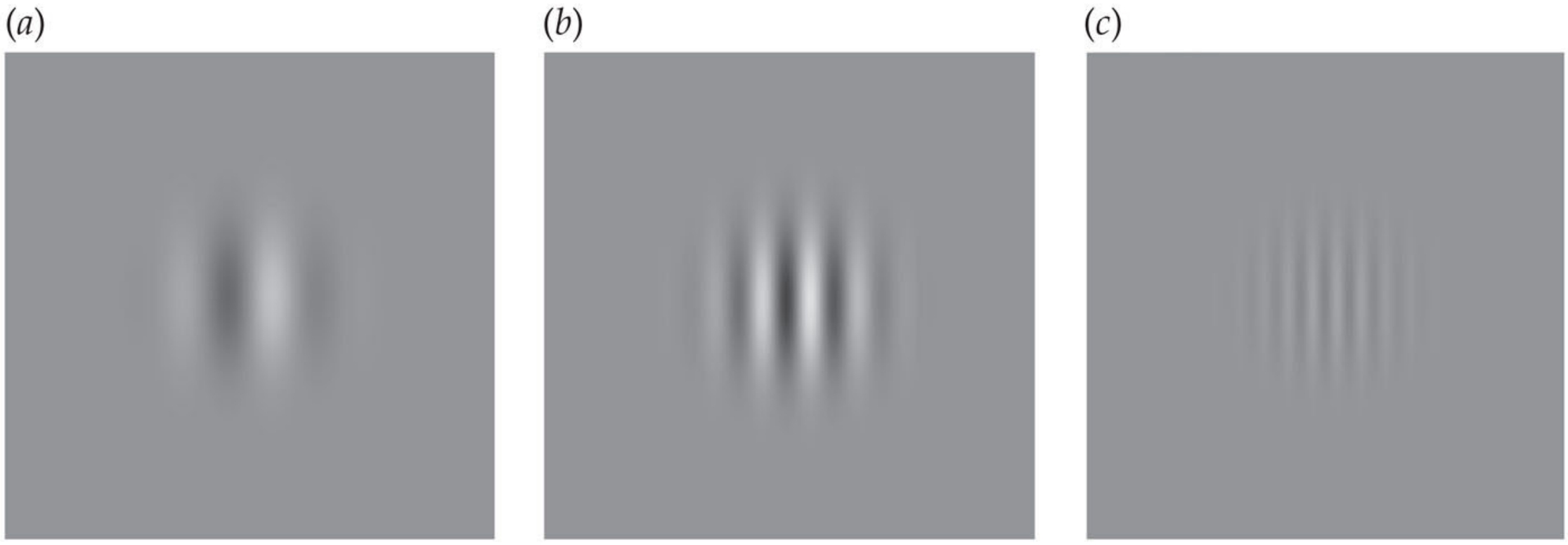

Luminanza
L_{max}
a
L_0
L_{min}
Spazio


SF=1/λ
λ
Luminanza
a
L_0
Spazio



***SENSATION & PERCEPTION 4e*, Figure 1.16**

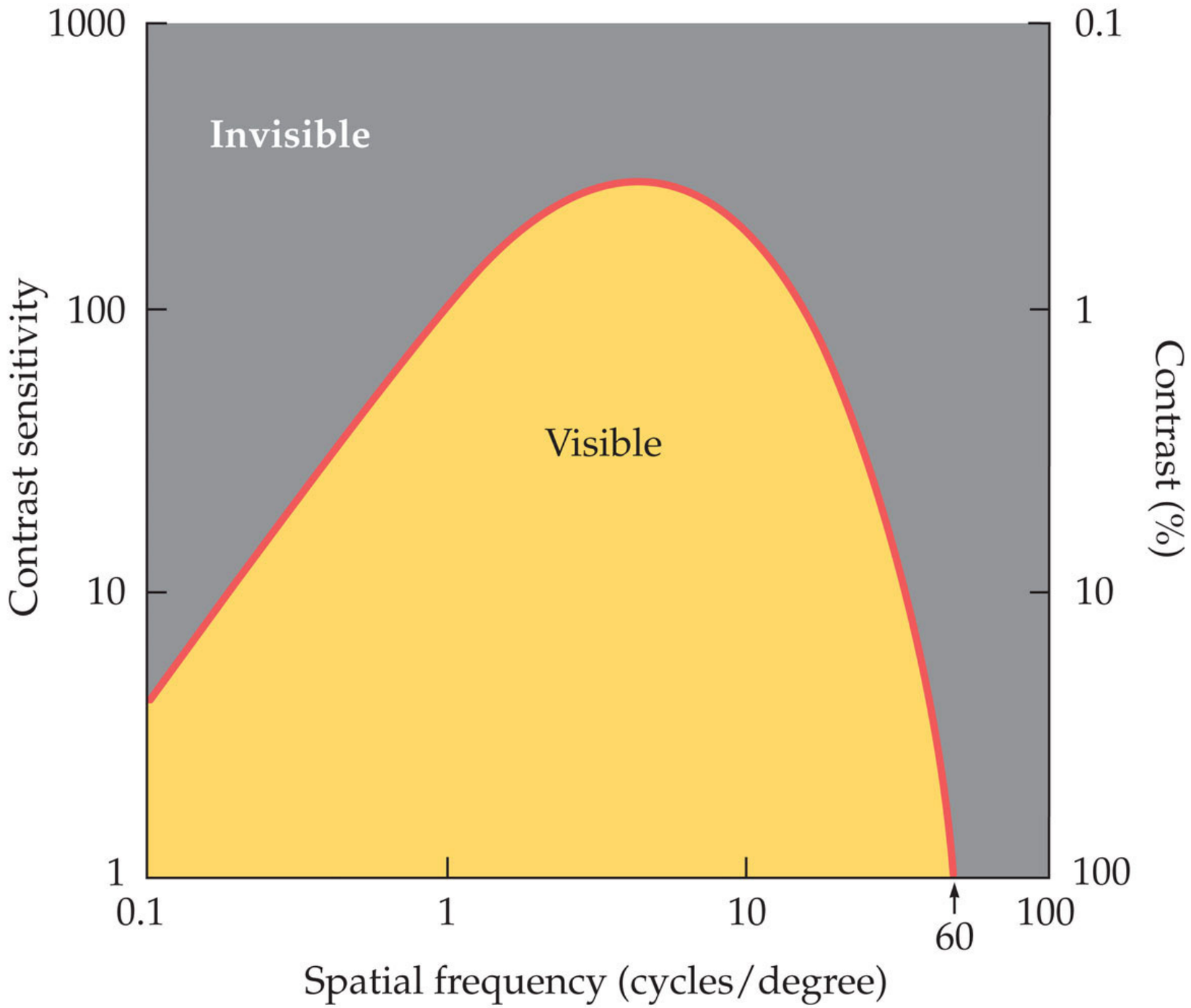
three **gratings** (Gabor patches)



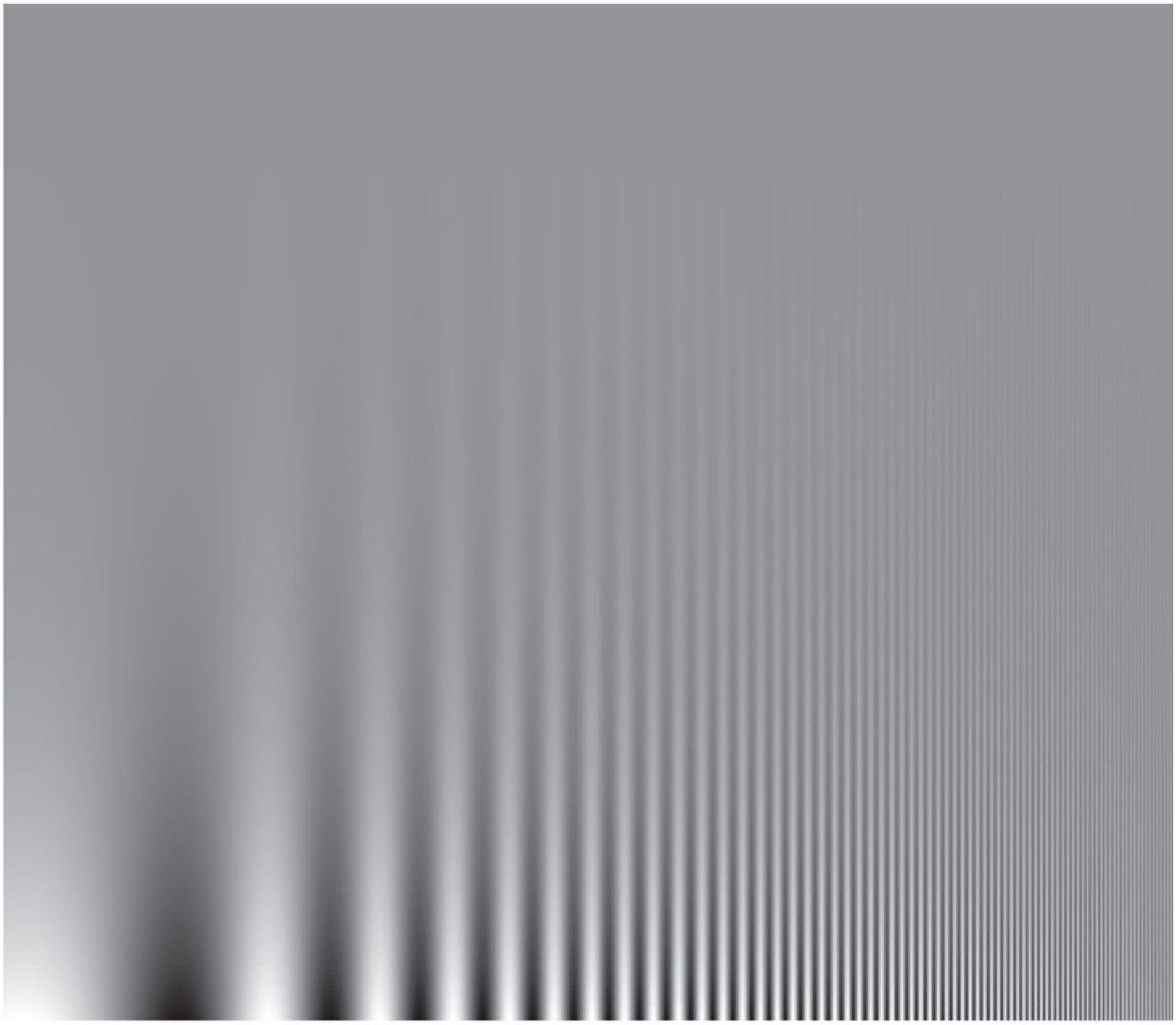
***SENSATION & PERCEPTION 4e*, Figure 3.6**

having **equal contrast** but
different **spatial frequency**

contrast sensitivity function

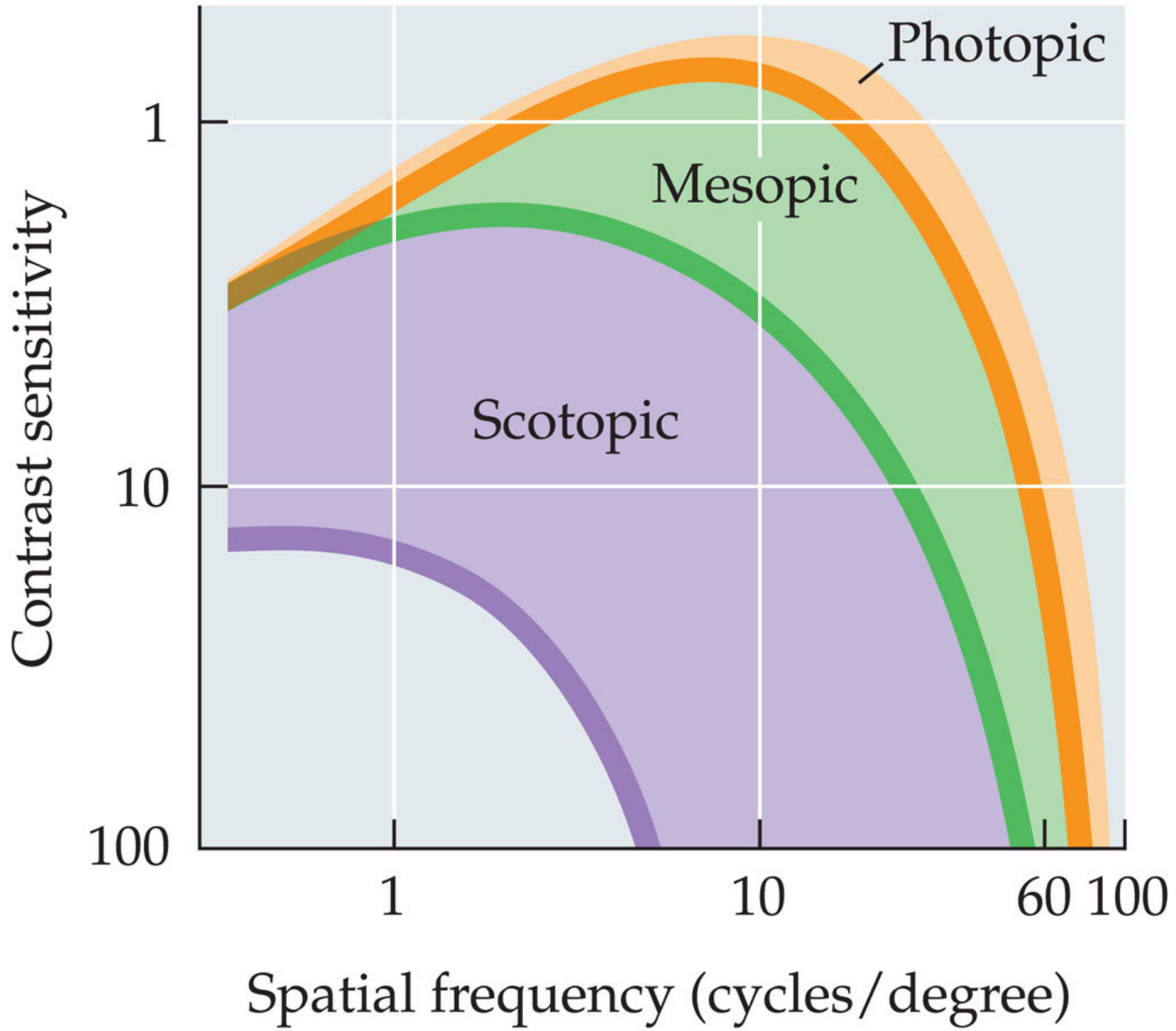


***SENSATION & PERCEPTION 4e*, Figure 3.7**



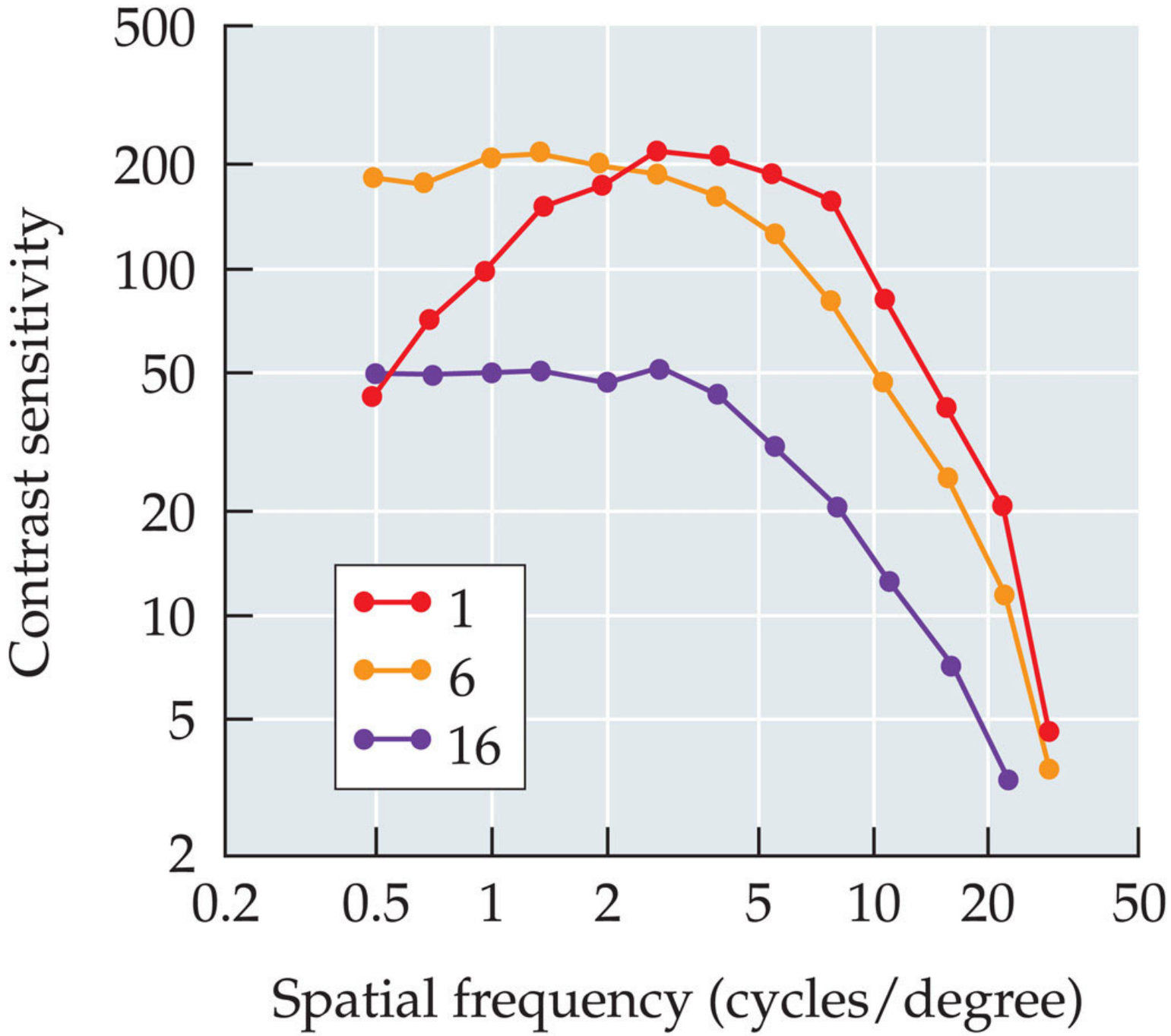
***SENSATION & PERCEPTION 4e,* Figure 3.8**

(*a*) Adaptation level

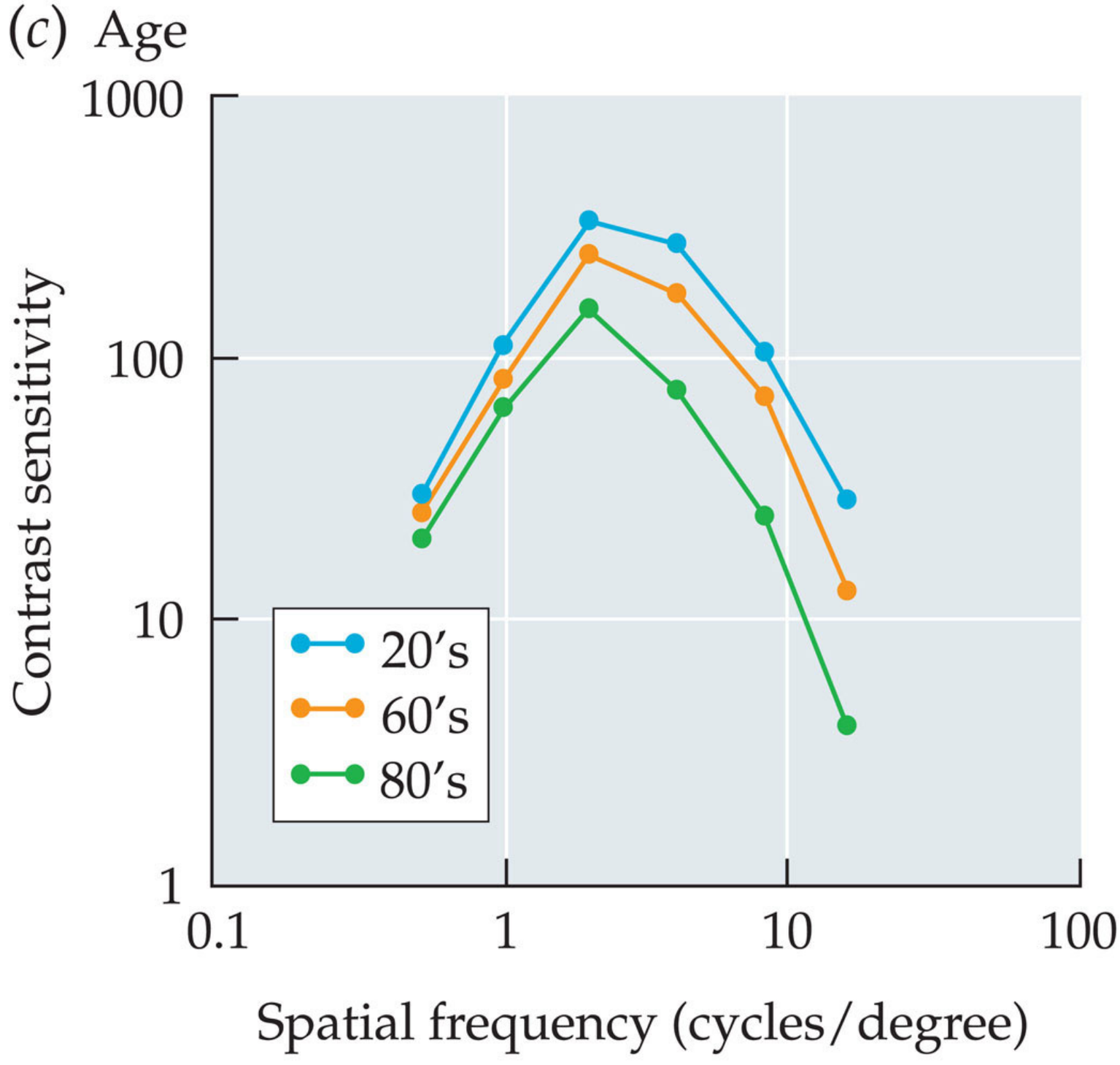


***SENSATION & PERCEPTION 4e,* Figure 3.9 (Part 1)**

(*b*) Temporal modulation

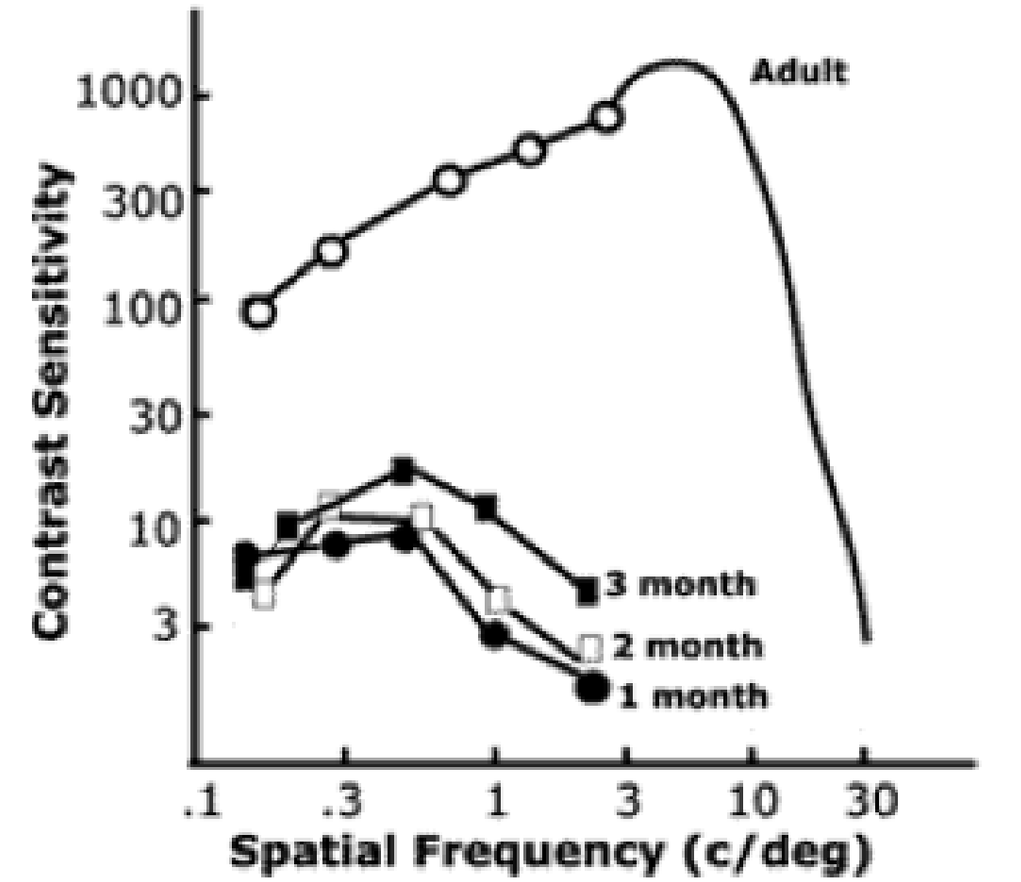


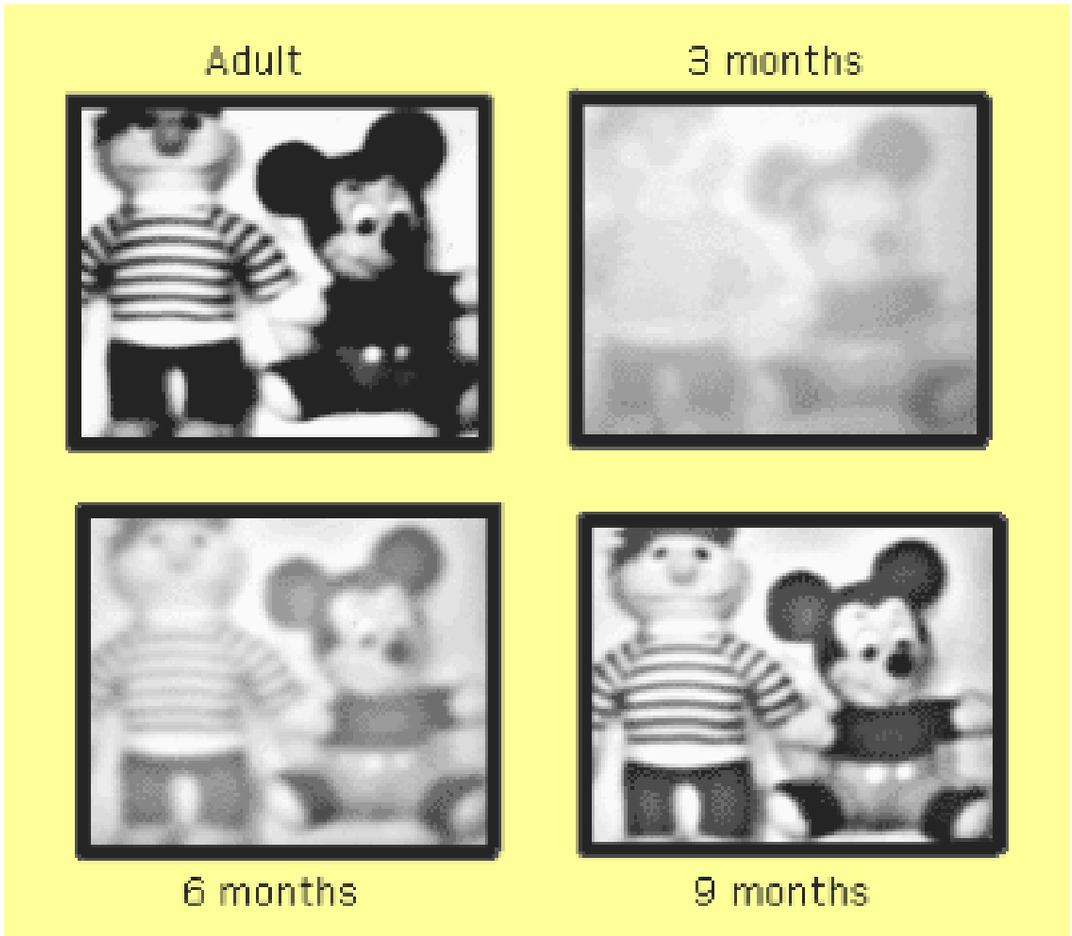
***SENSATION & PERCEPTION 4e,* Figure 3.9 (Part 2)**



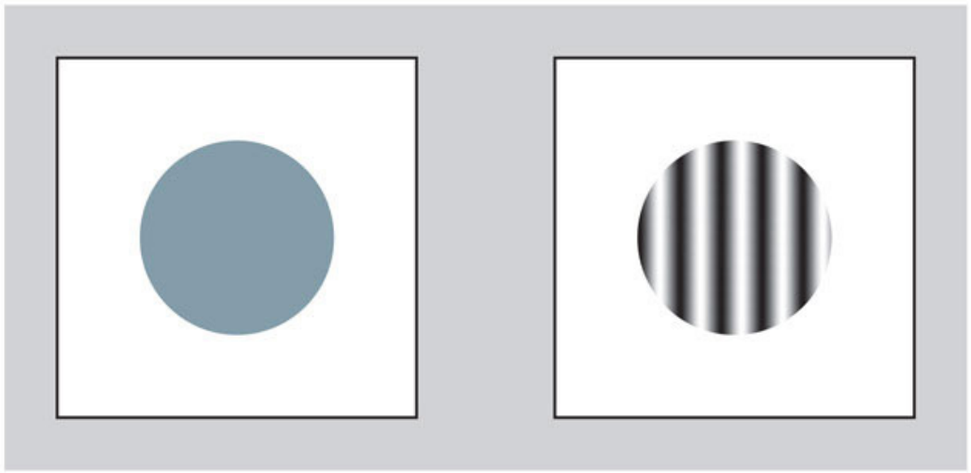
***SENSATION & PERCEPTION 4e*, Figure 3.9 (Part 3)**

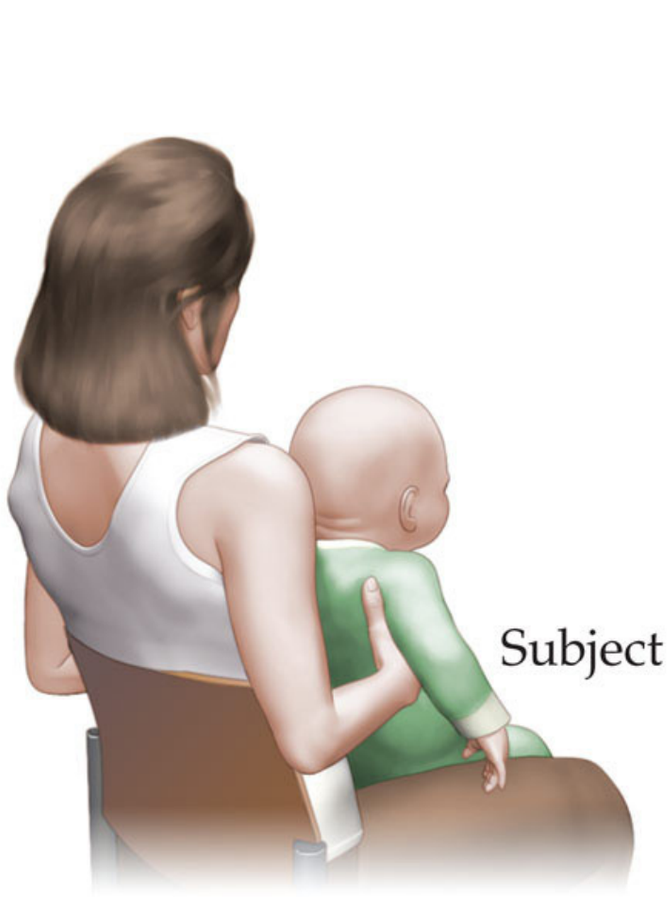
CSF e sviluppo

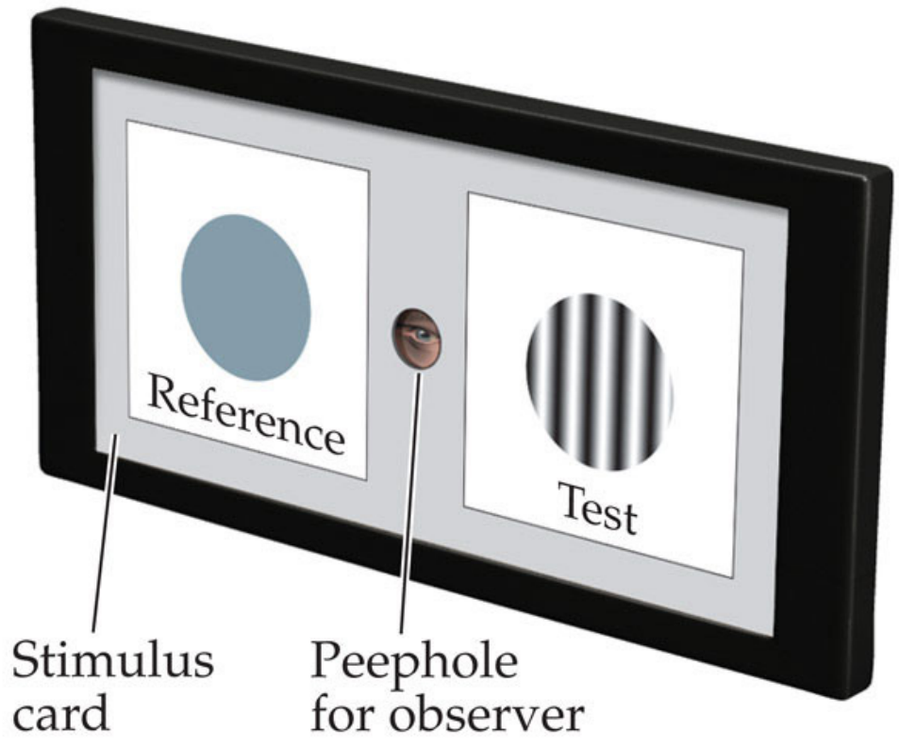




(*a*) Stimulus card

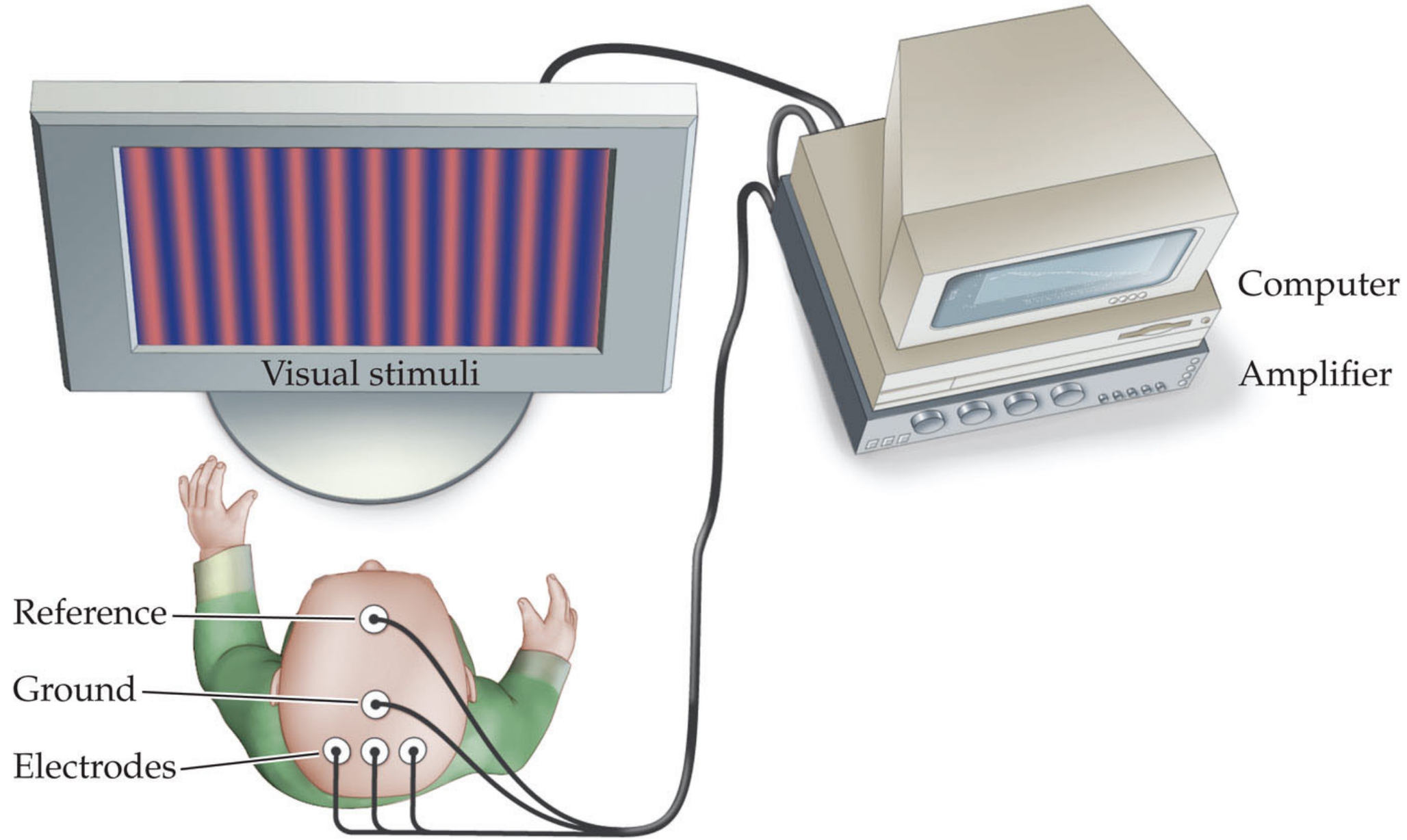






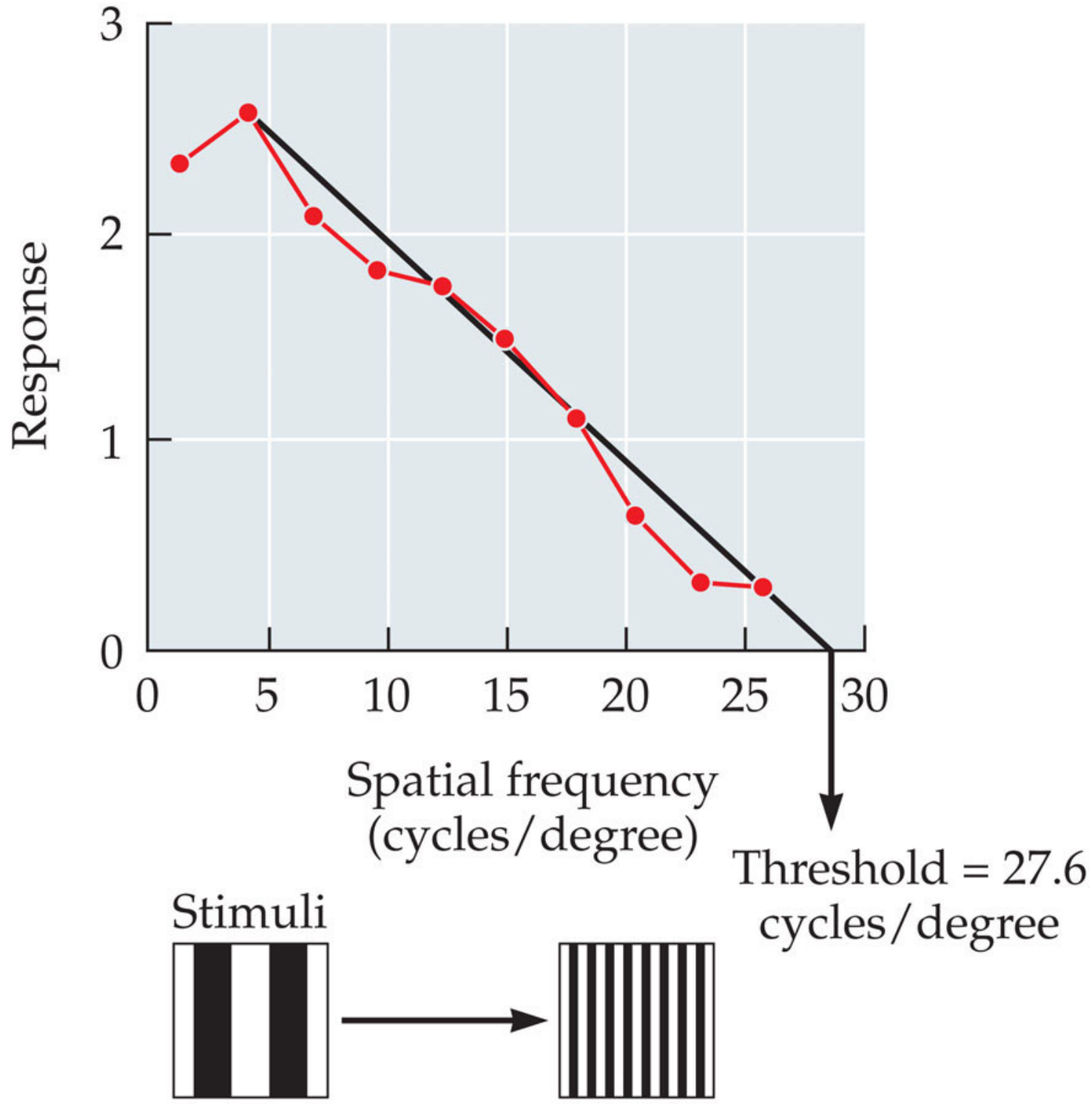
***SENSATION & PERCEPTION 4e*, Figure 3.36 (Part 1)**

(*b*)



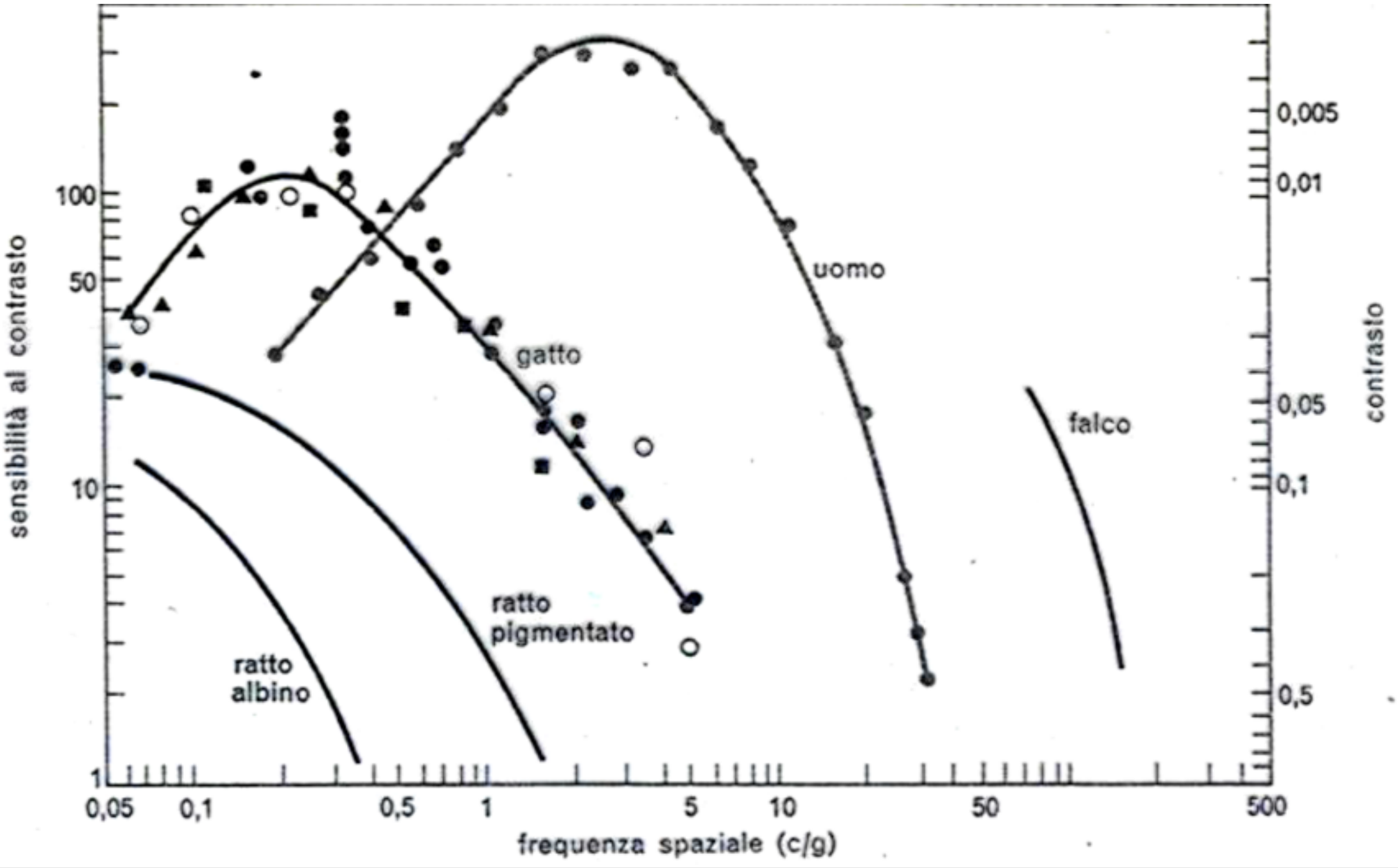
***SENSATION & PERCEPTION 4e,* Figure 3.36 (Part 2)**

(*c*) Sweep VEP (grating acuity)

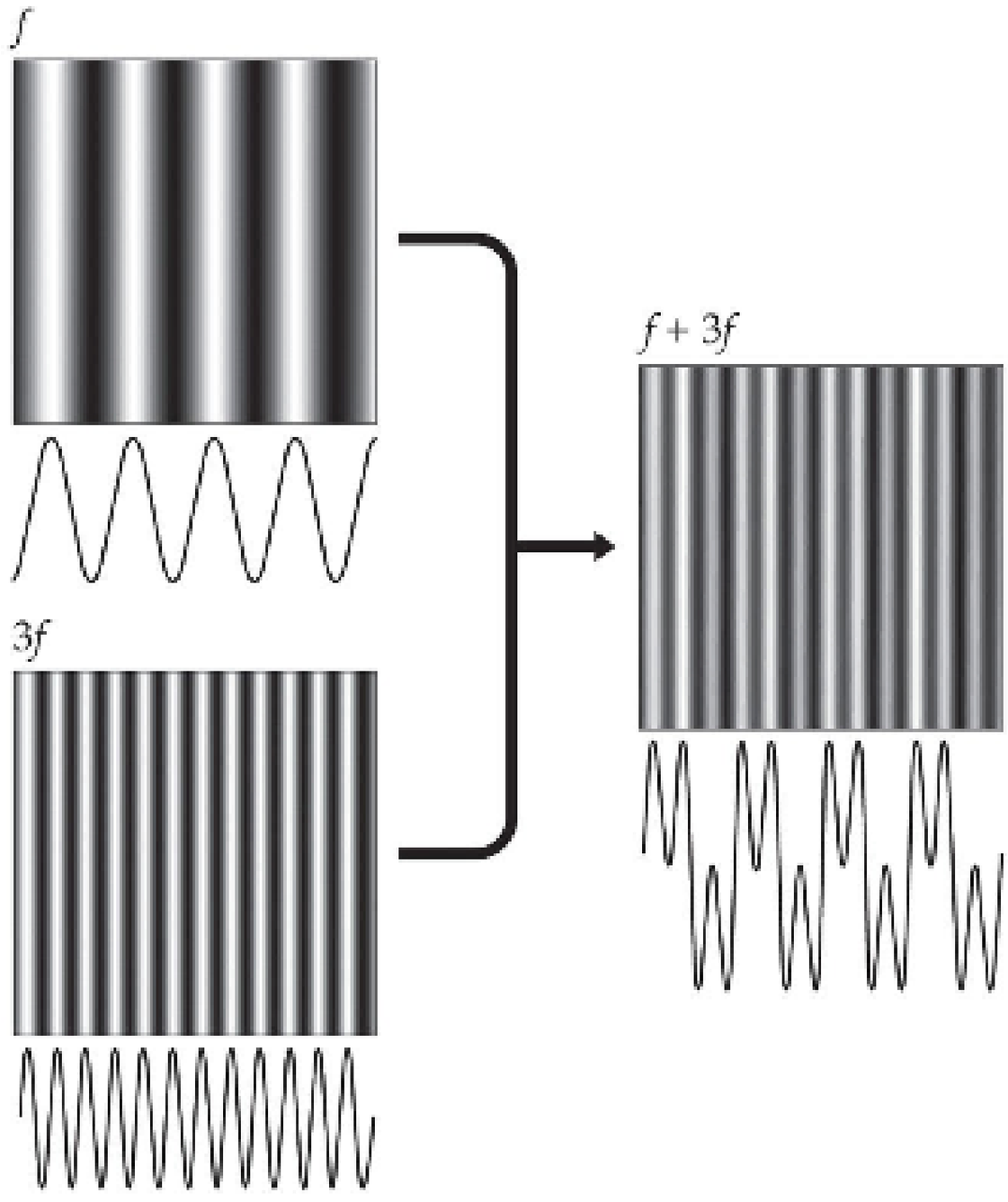


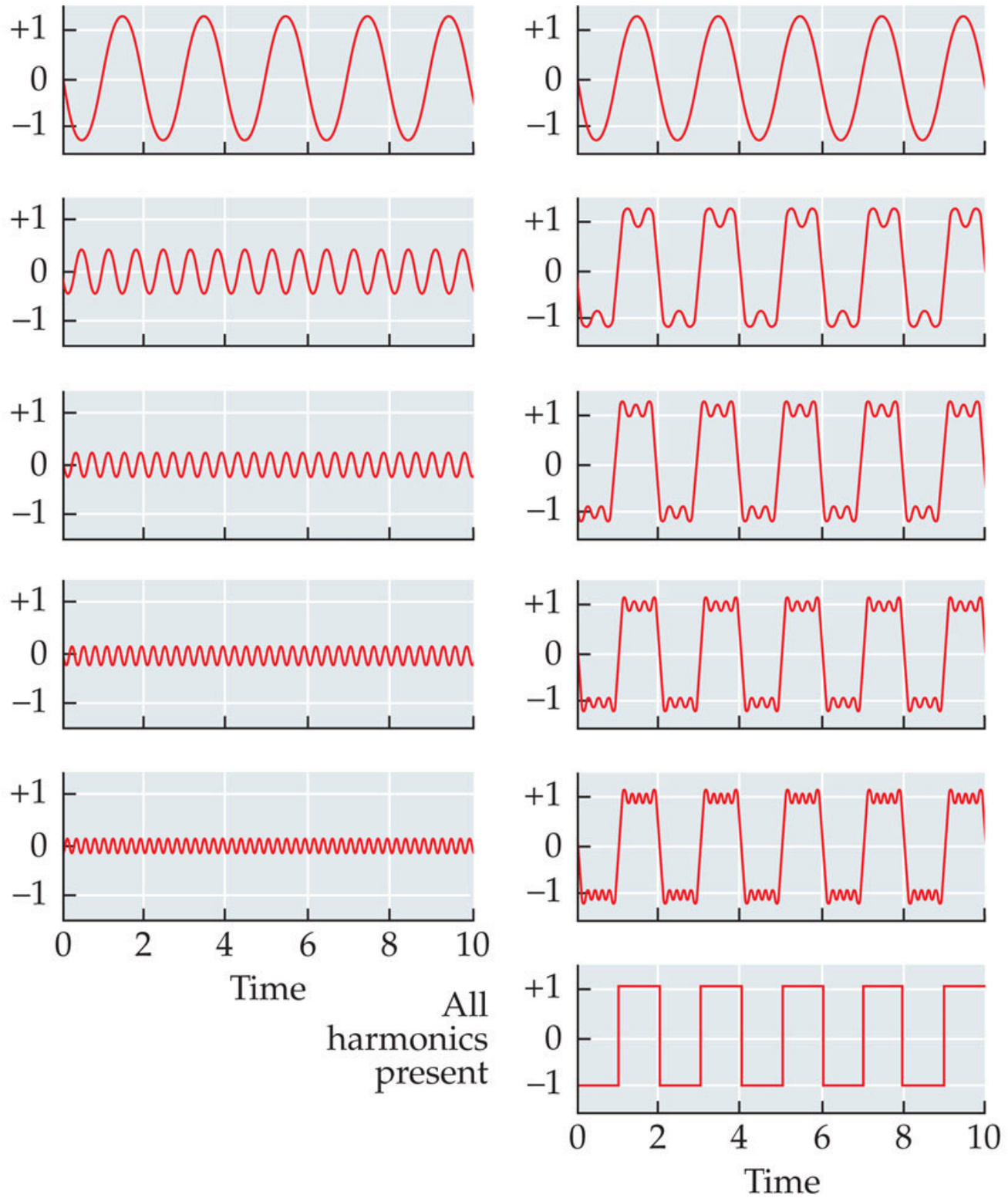
***SENSATION & PERCEPTION 4e,* Figure 3.36 (Part 3)**

CSF in diverse specie



somme di reticoli





***SENSATION & PERCEPTION 4e*, Figure 3.10**

J. Physiol. (1968), **197**, *pp.* 551–566
With 7 text-figures
Printed in Great Britain

APPLICATION OF FOURIER ANALYSIS TO THE VISIBILITY OF GRATINGS

BY F. W. CAMPBELL AND J. G. ROBSON
From the Physiological Laboratory, University of Cambridge

(*Received* 10 *November* 1967)

SUMMARY

1. The contrast thresholds of a variety of grating patterns have been measured over a wide range of spatial frequencies.

2. Contrast thresholds for the detection of gratings whose luminance profiles are sine, square, rectangular or saw-tooth waves can be simply related using Fourier theory.

3. Over a wide range of spatial frequencies the contrast threshold of a grating is determined only by the amplitude of the fundamental Fourier component of its wave form.

4. Gratings of complex wave form cannot be distinguished from sine-wave gratings until their contrast has been raised to a level at which the higher harmonic components reach their independent threshold.

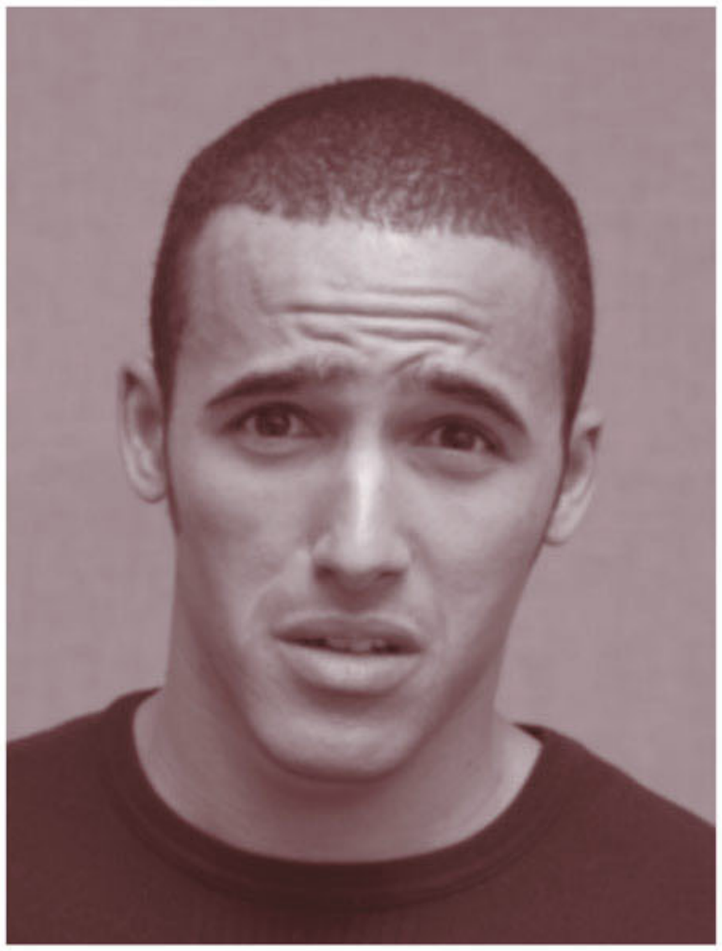
5. These findings can be explained by the existence within the nervous system of linearly operating independent mechanisms selectively sensitive to limited ranges of spatial frequencies.

immagini naturali

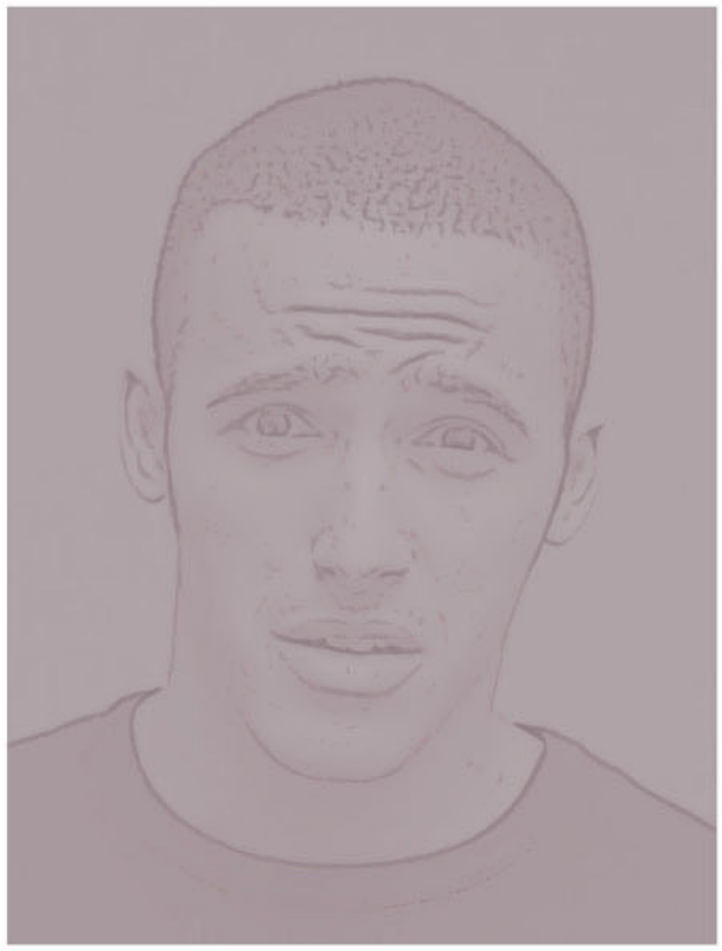
componenti a bassa frequenza

componenti ad alta frequenza

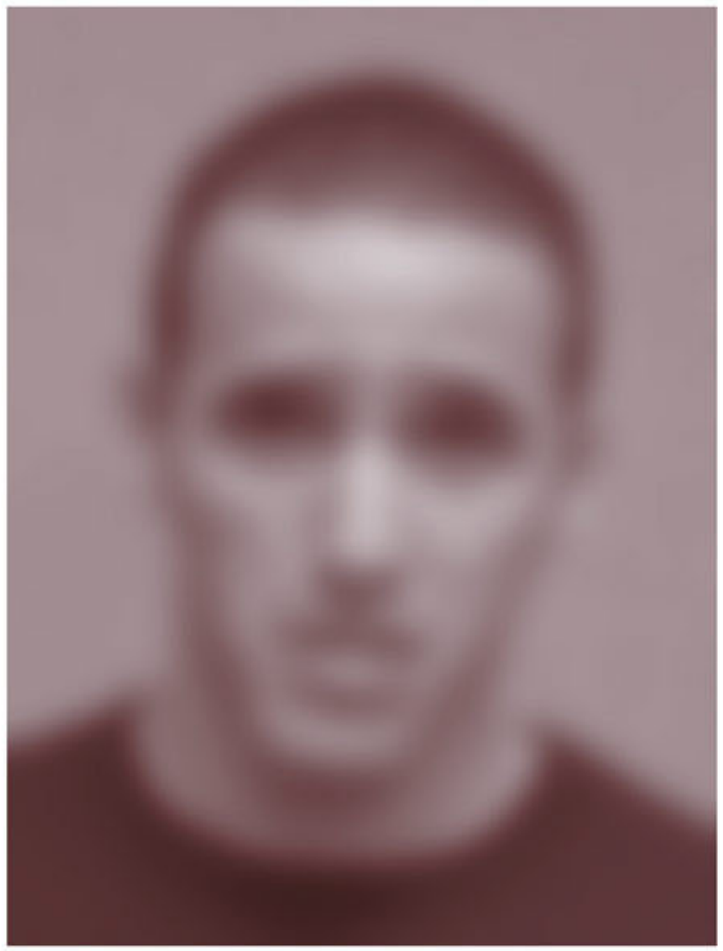
(*a*)



(*b*)

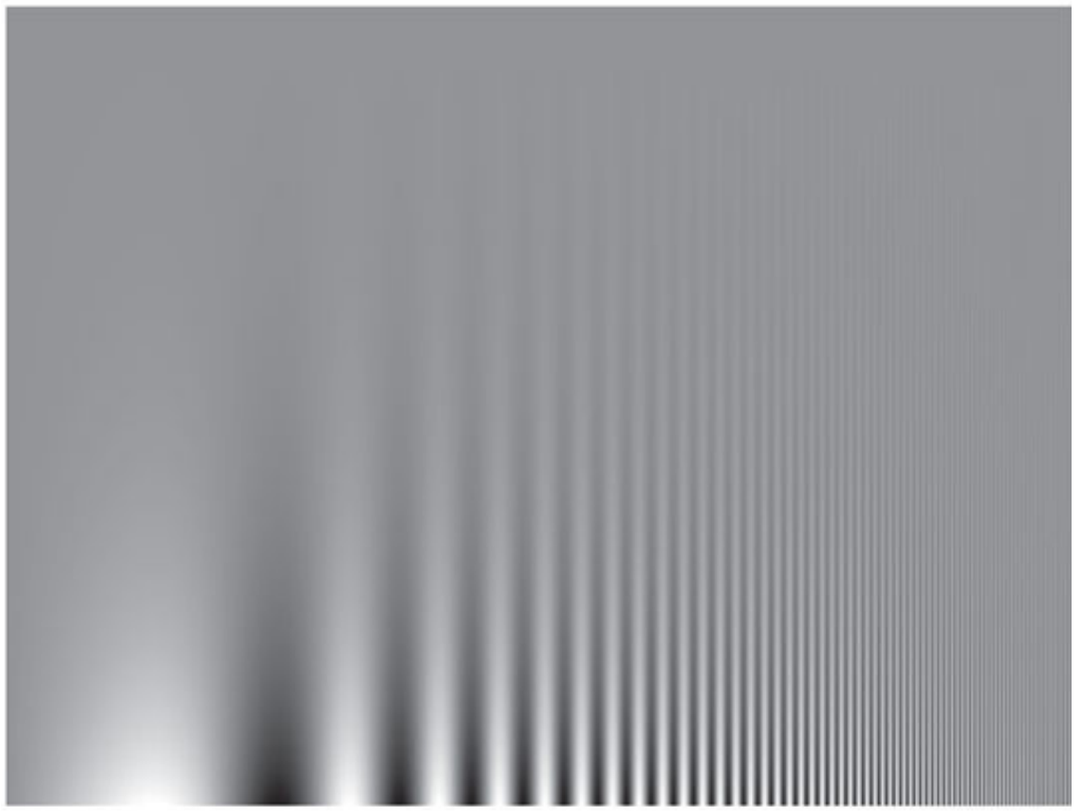


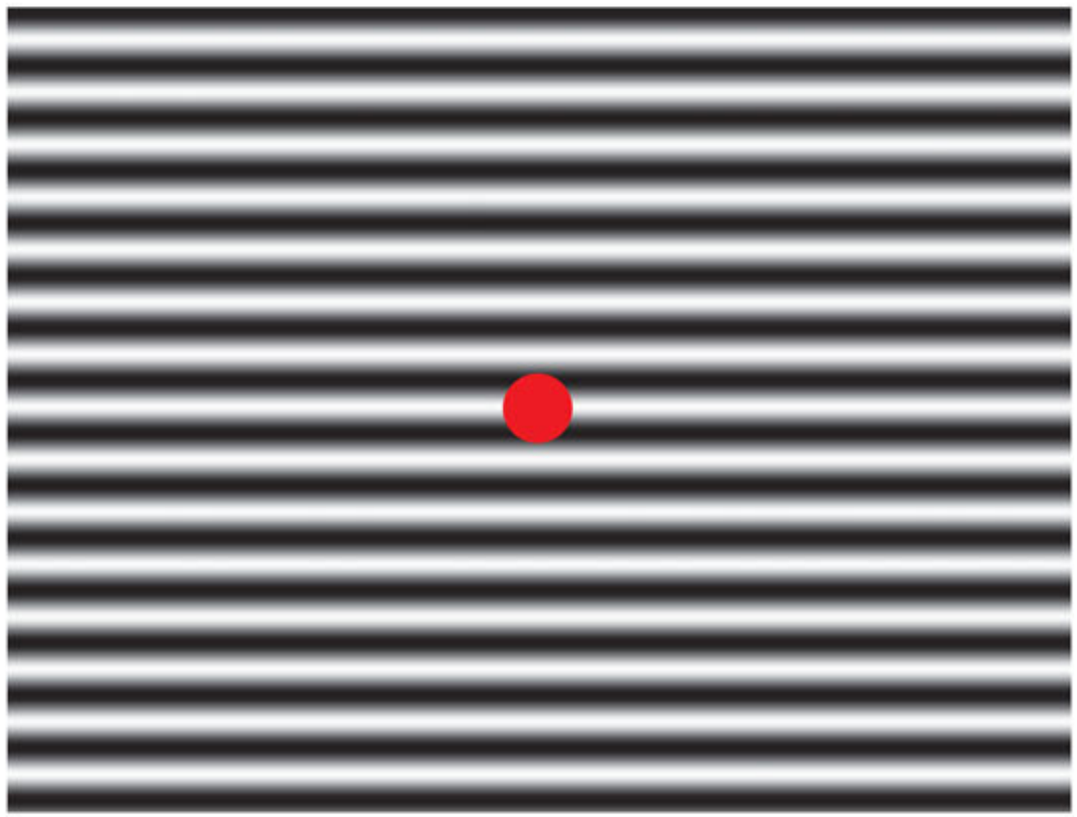
(*c*)

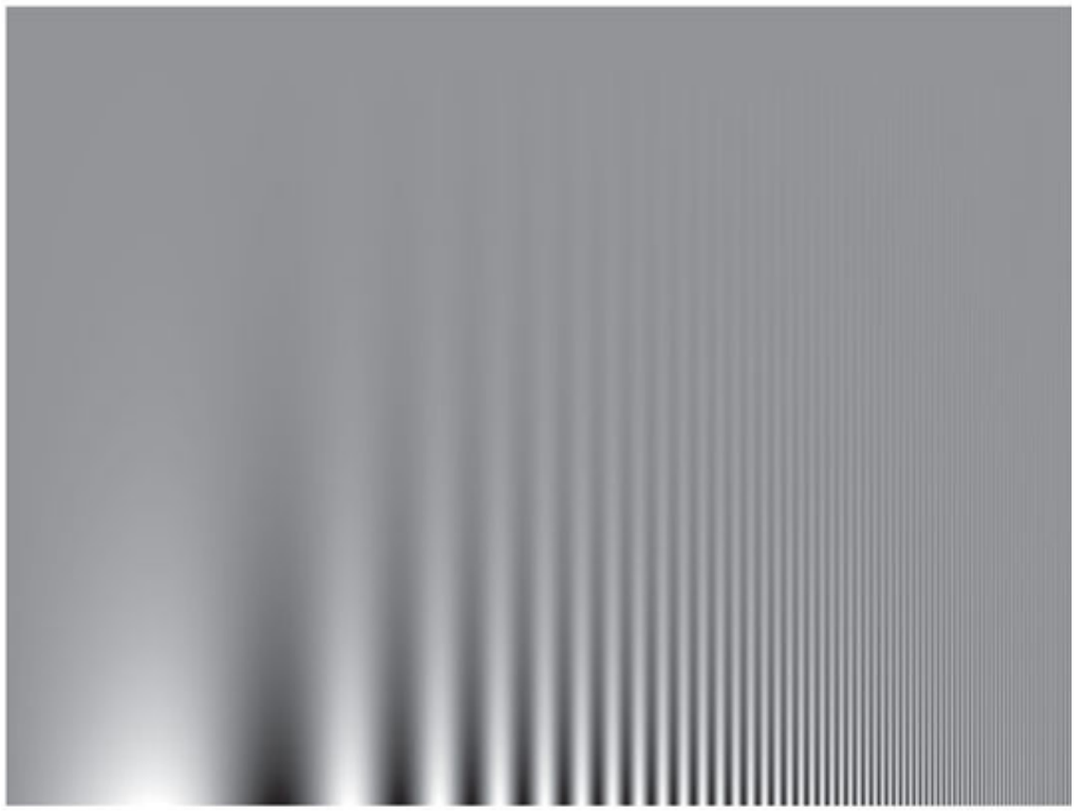


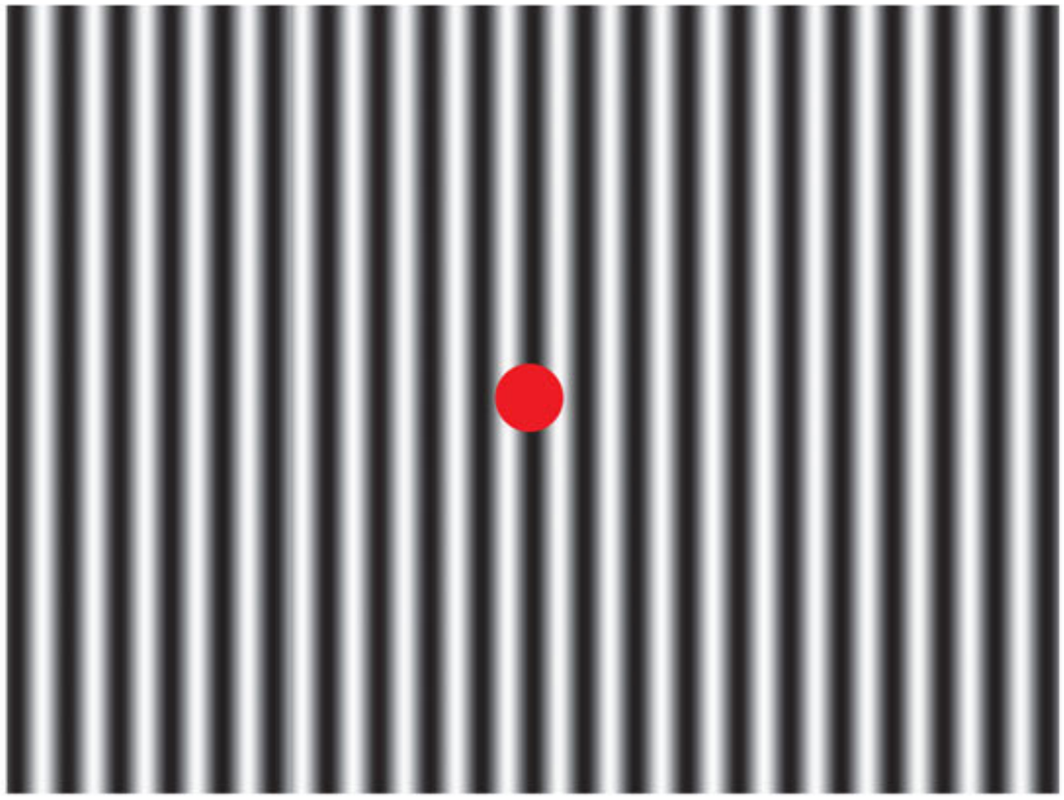
***SENSATION & PERCEPTION 4e,* Figure 3.34**

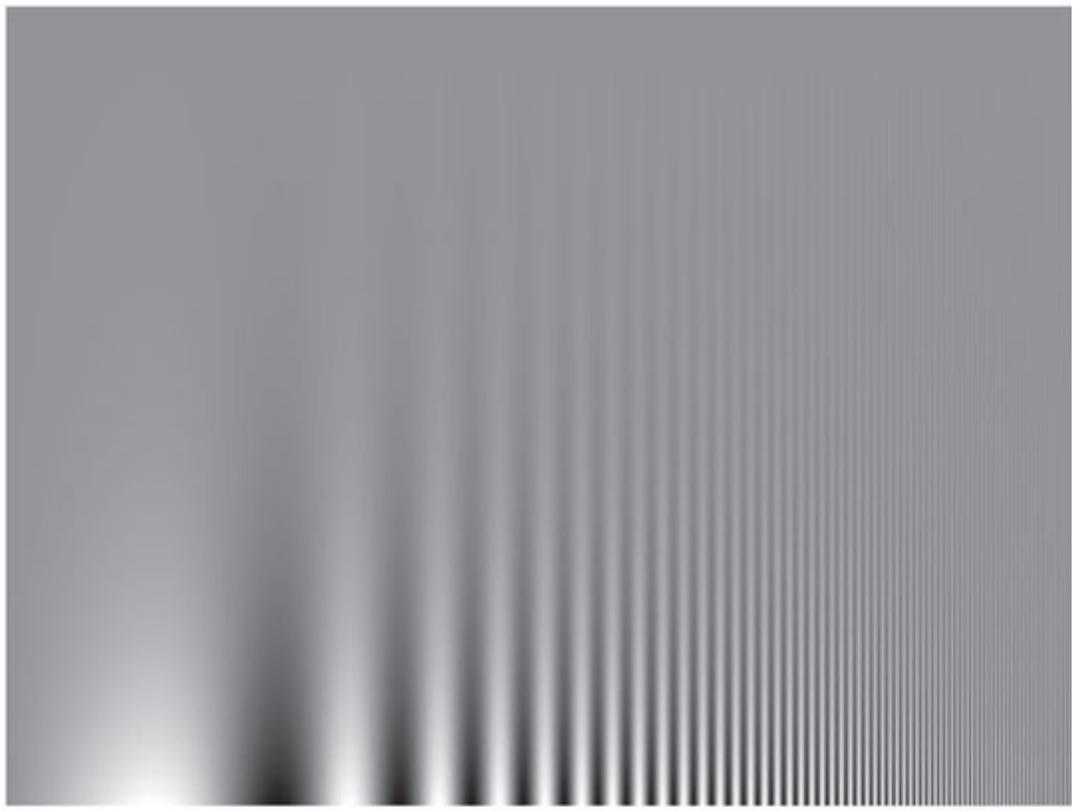
SF adaptation demo: test display



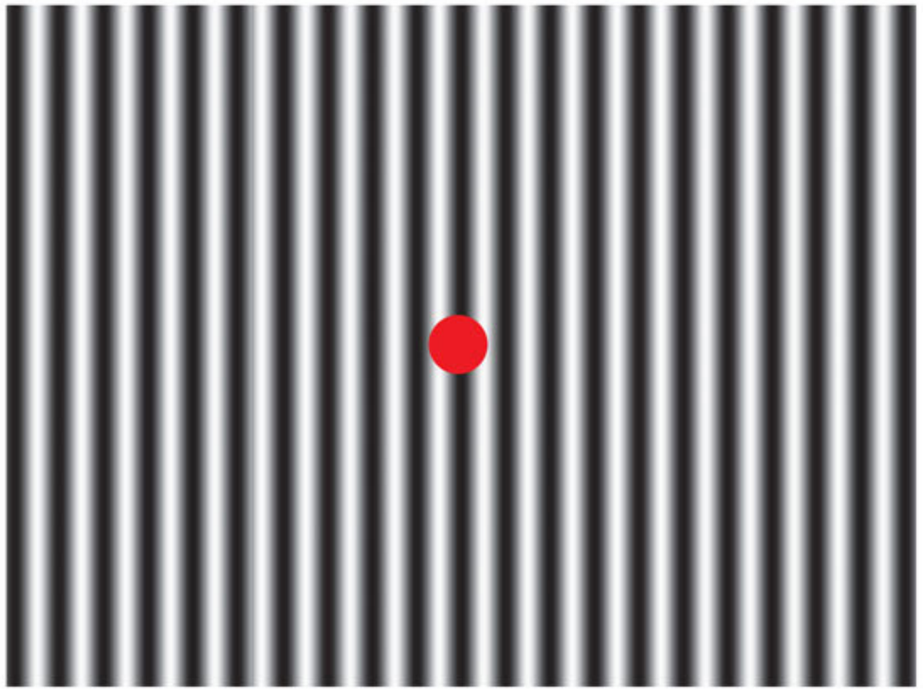




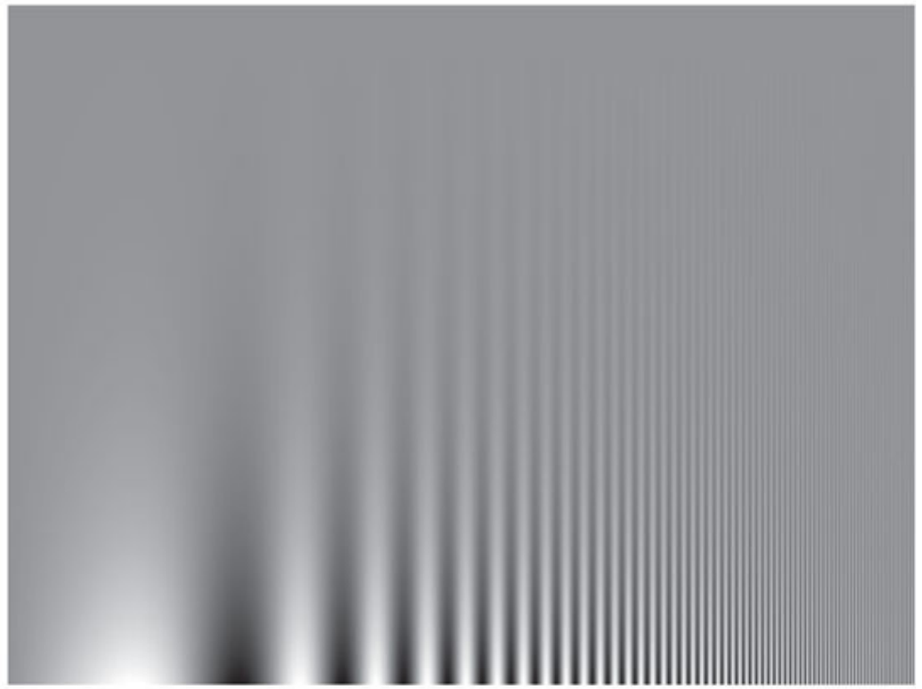




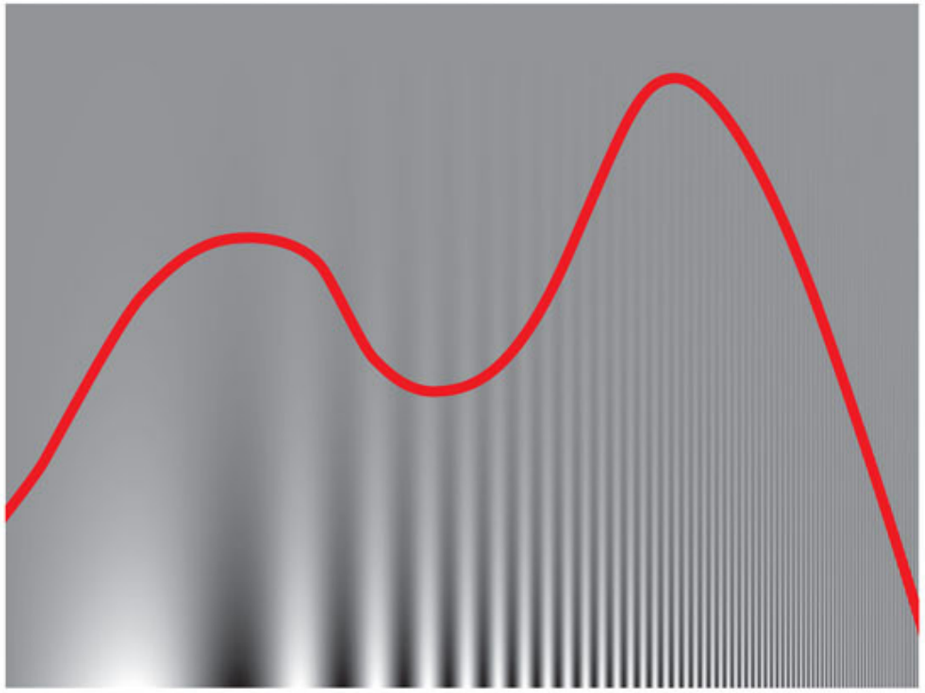
(a)



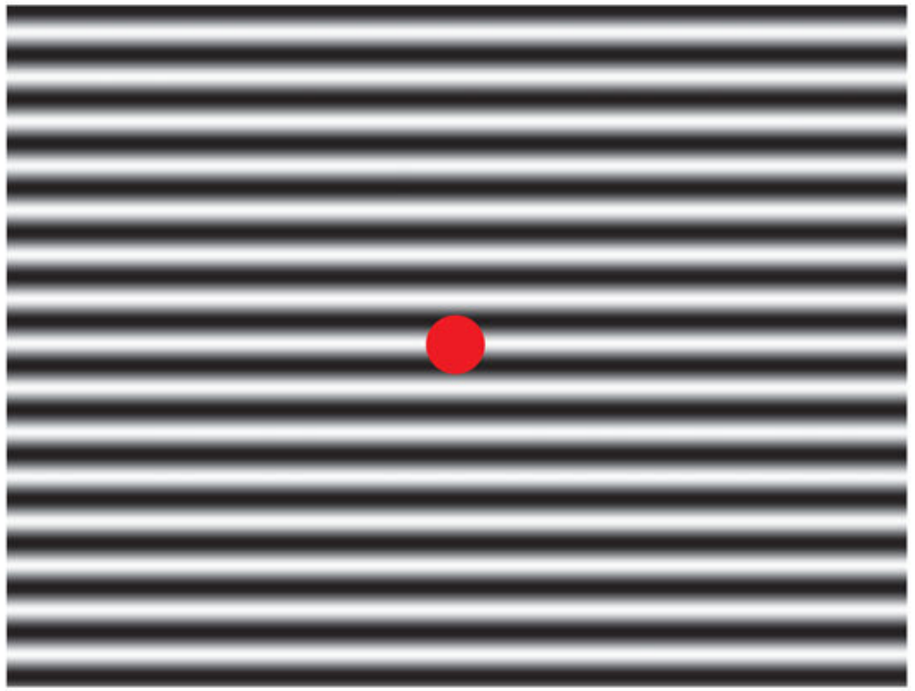
(b)



(c)

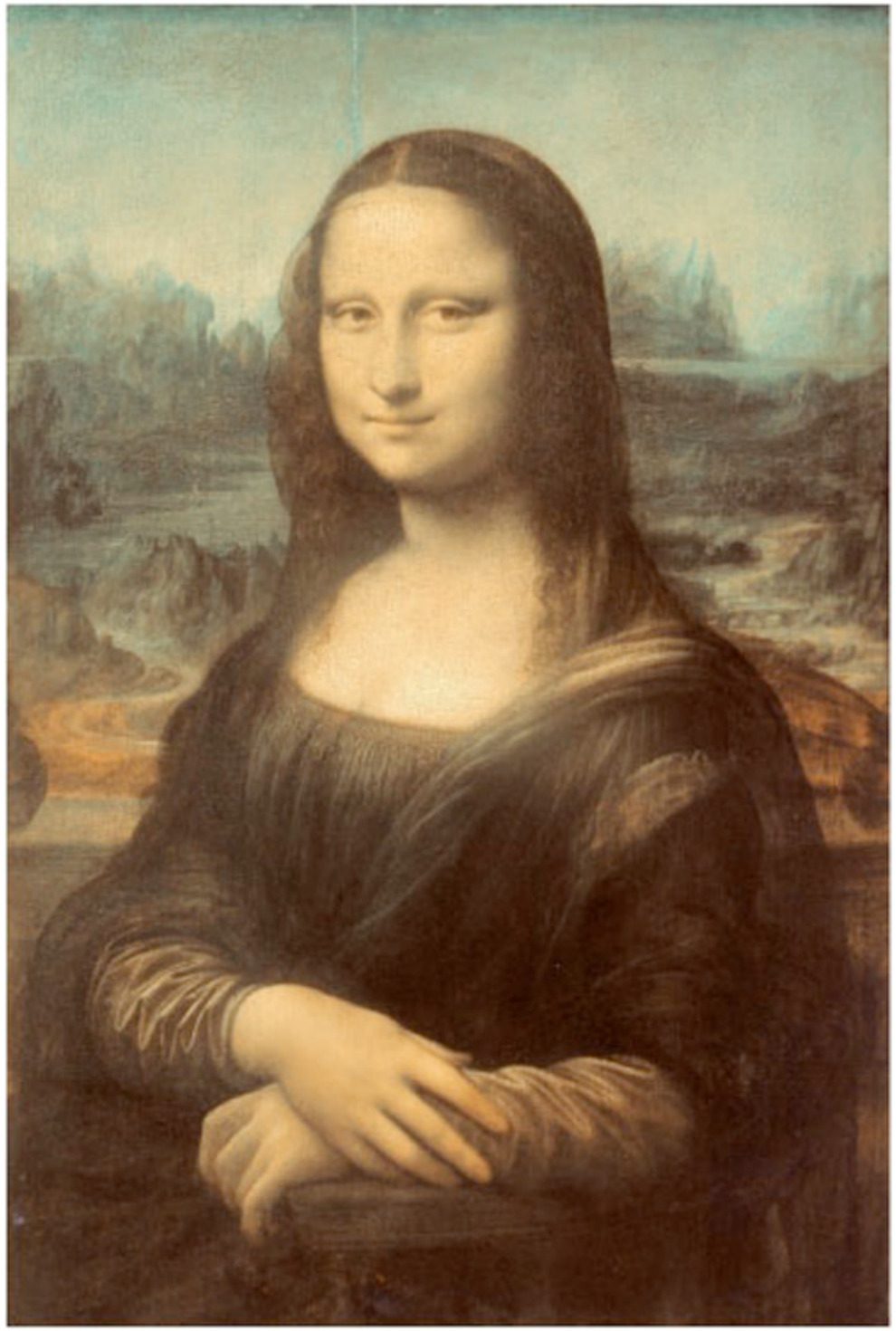


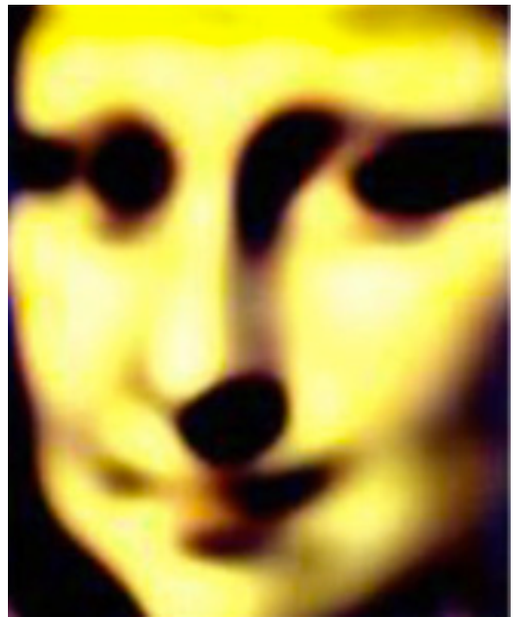
(d)

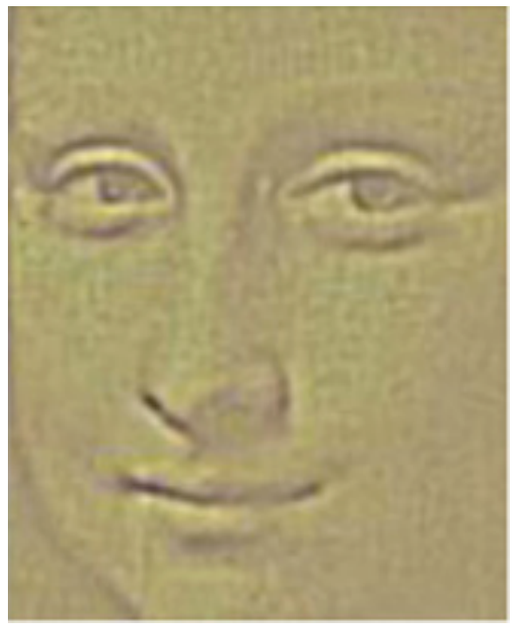


***SENSATION & PERCEPTION 4e,* Figure 3.31**

Dr. Angry & Mr. Smile







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Short Report

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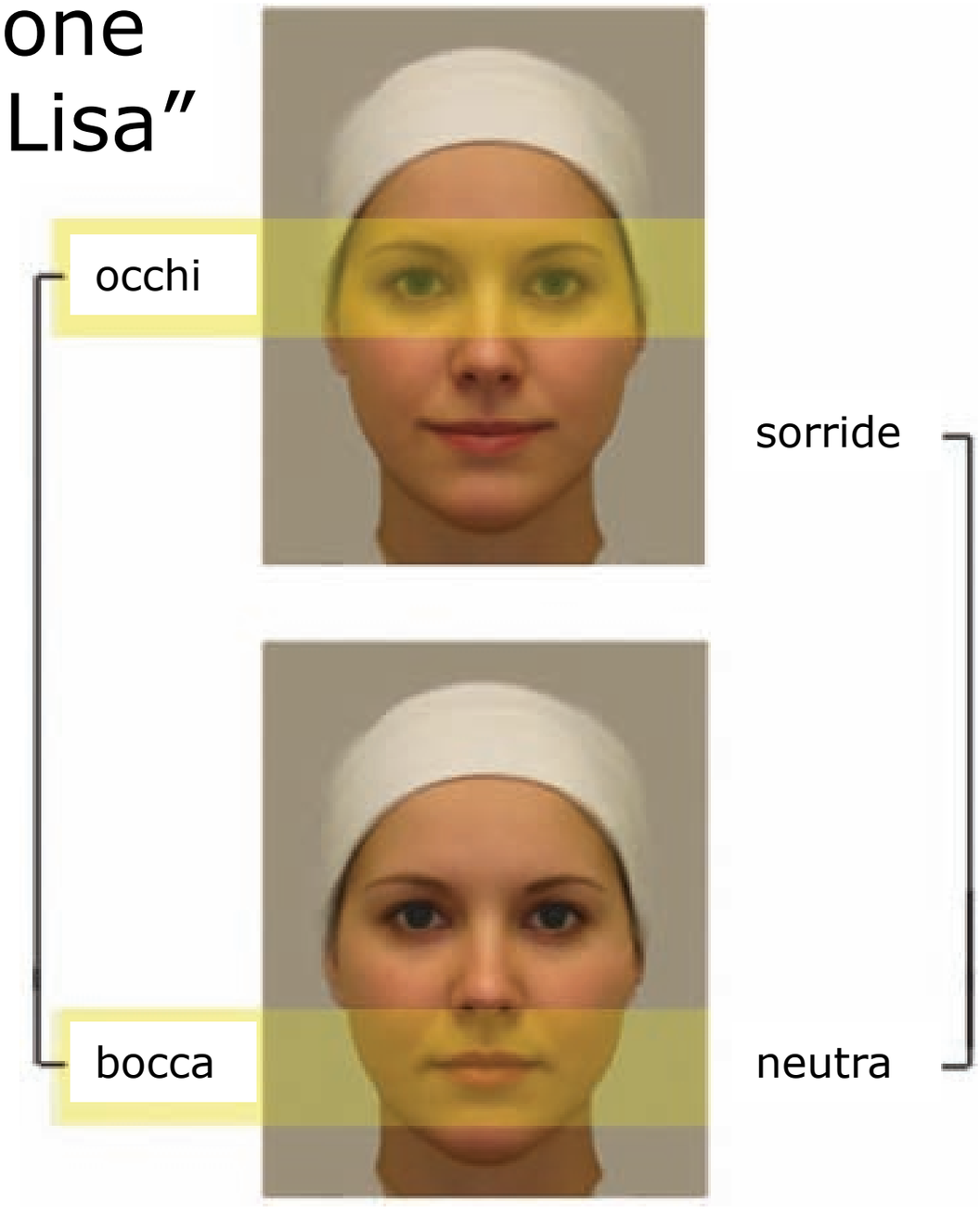
a

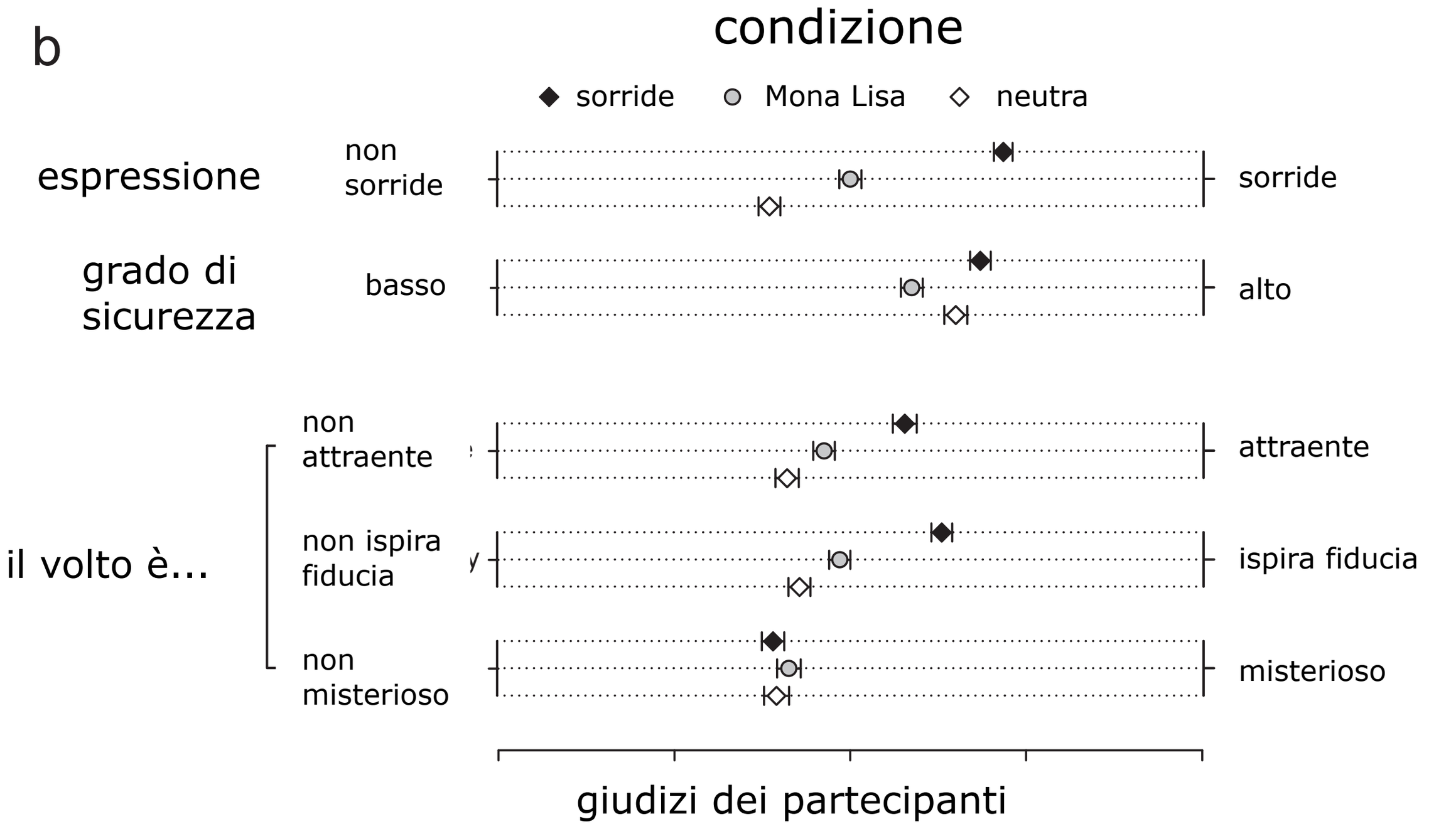
condizione
“Mona Lisa”



area di
fissazione del
partecipante

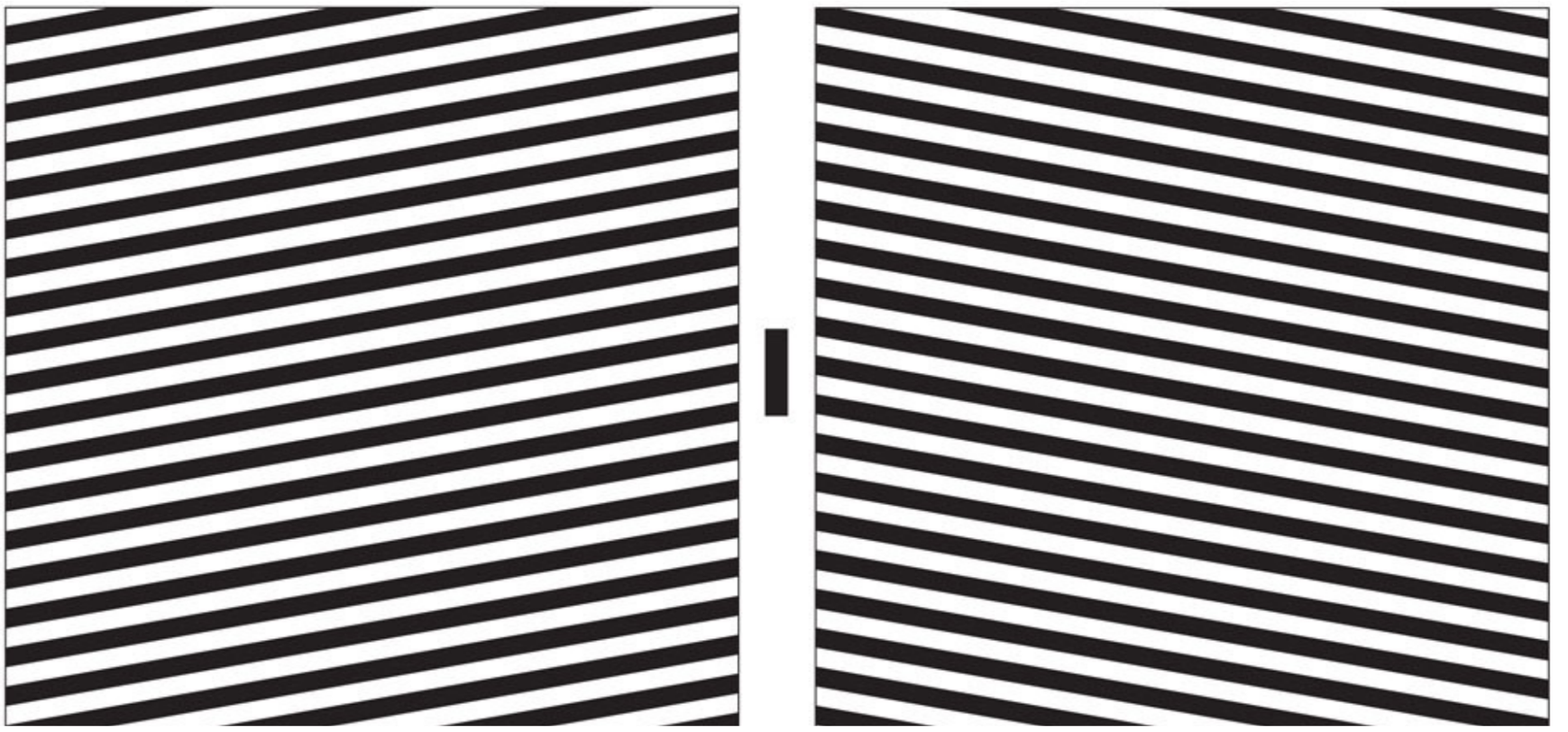
espressione
della bocca

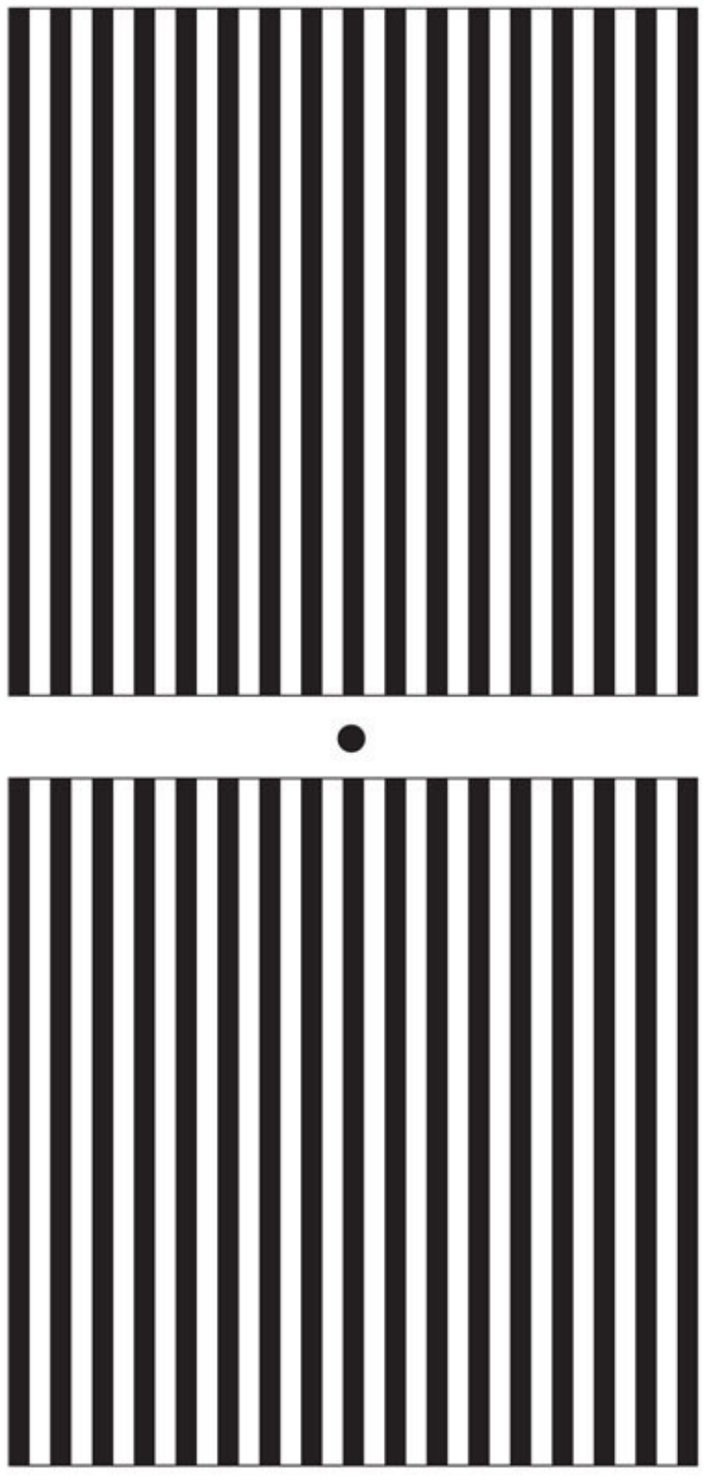
b

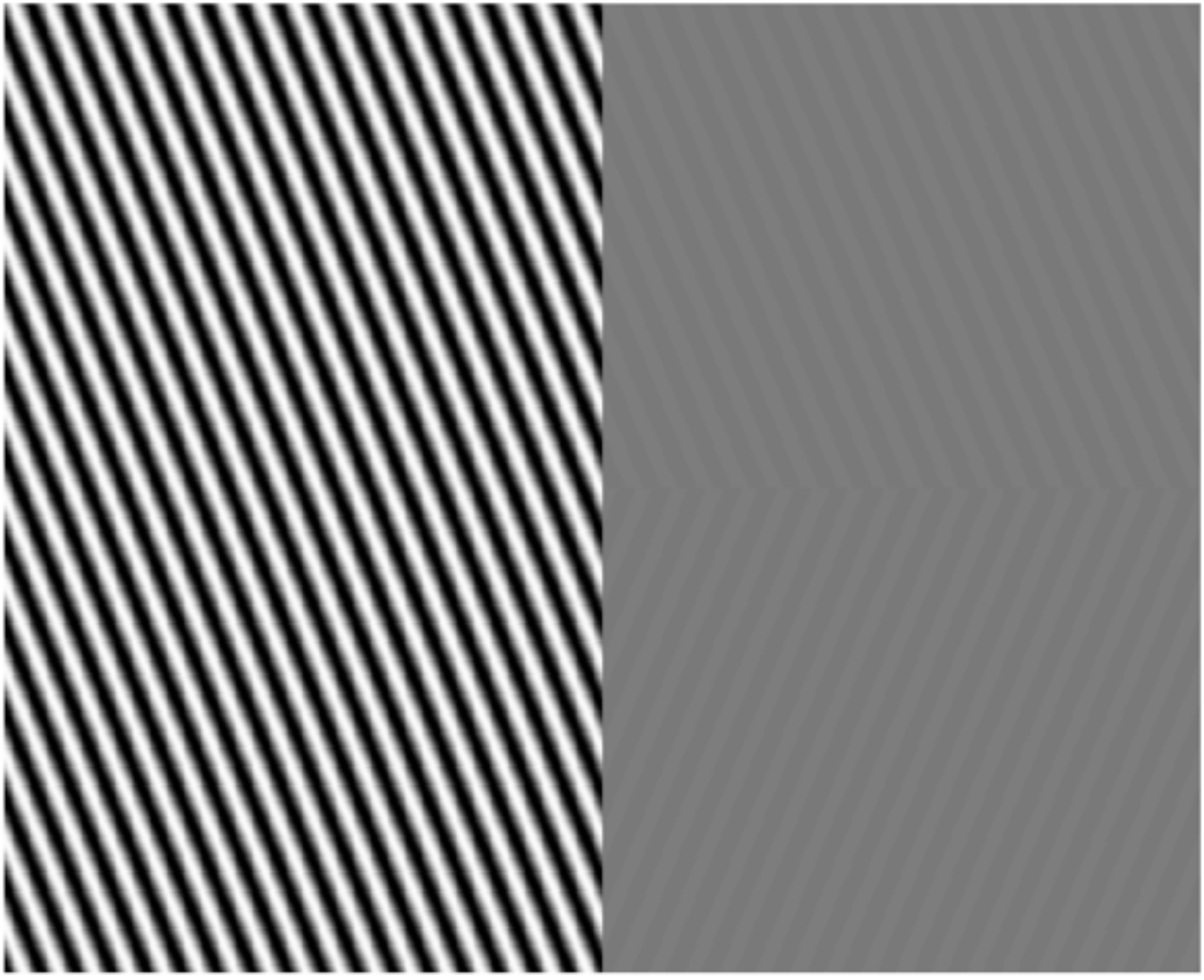

condizione
sorride
Mona Lisa
neutra
espressione
non sorride
sorride
grado di sicurezza
basso
alto
il volto è...
non attraente
attraente
non ispira fiducia
ispira fiducia
non misterioso
misterioso
giudizi dei partecipanti

Lezione 22-23

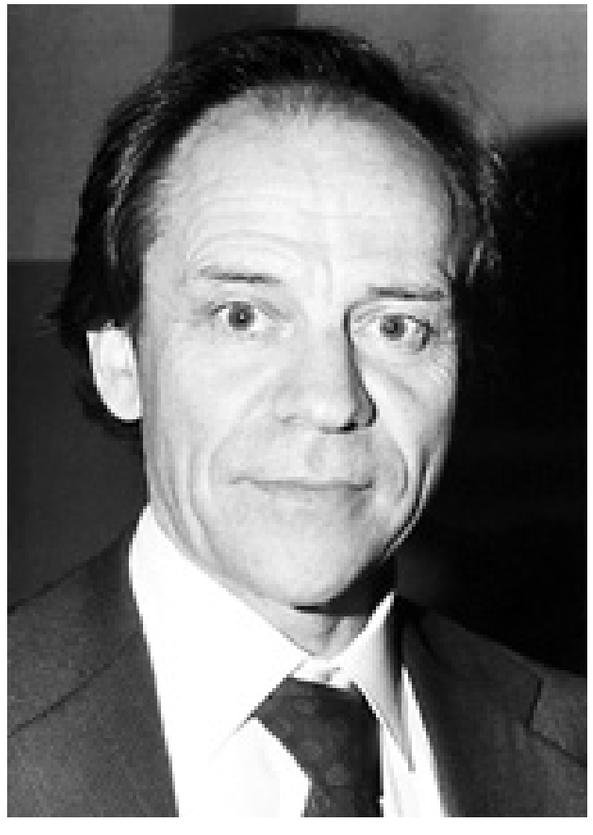
visione di basso livello: contrasto, frequenza spaziale e orientazione



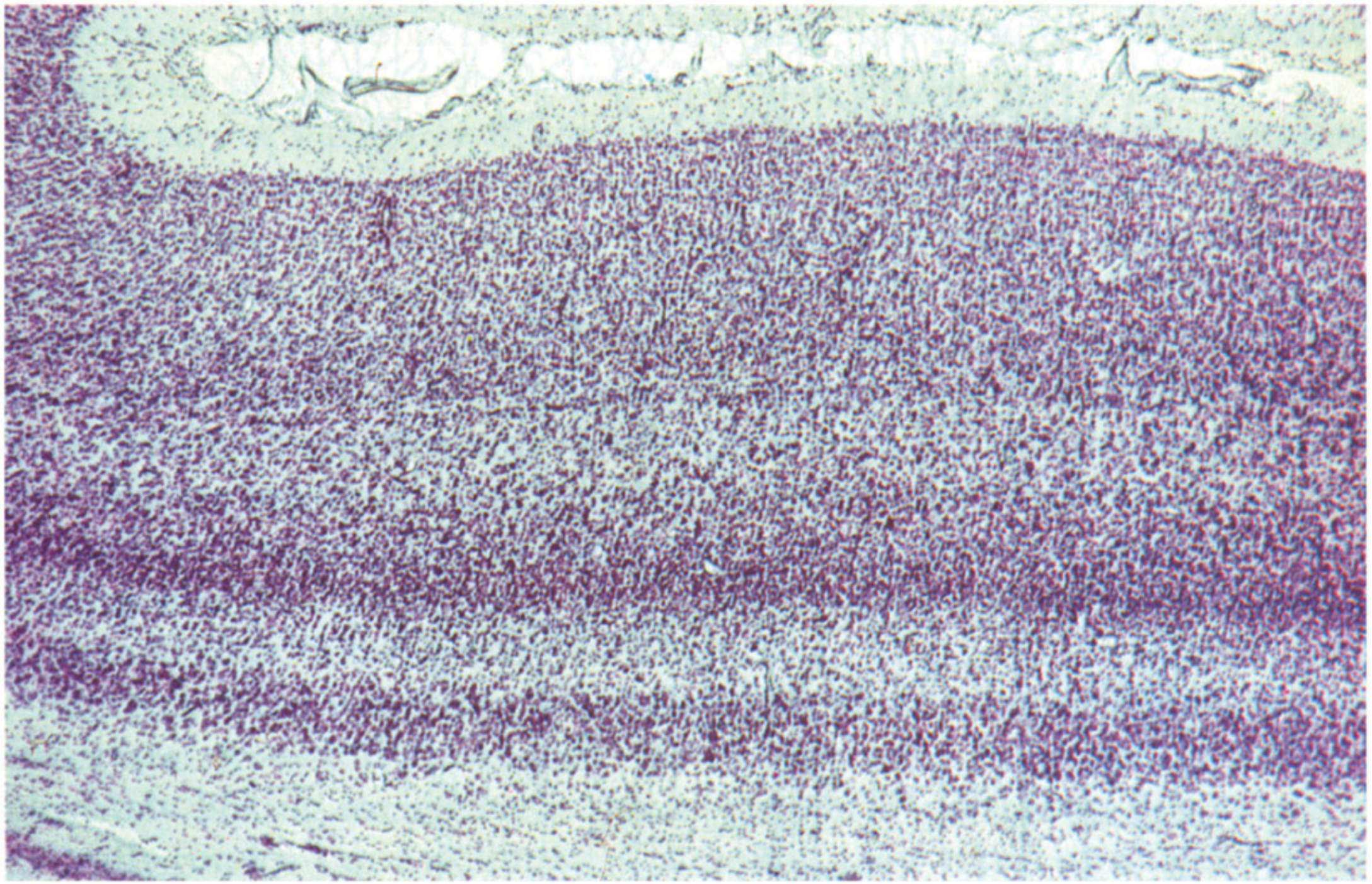


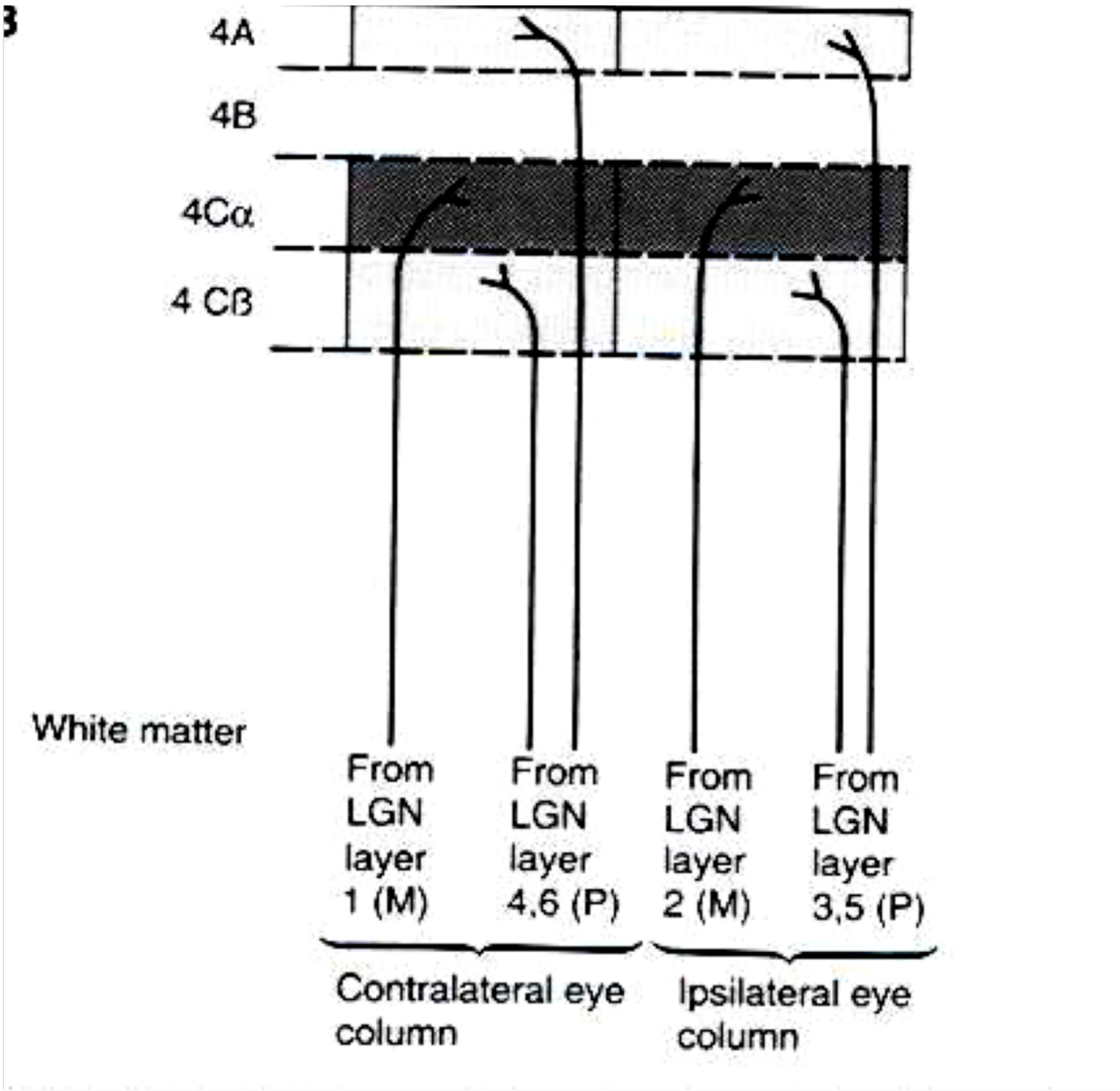


David Hubel (1926-)



Torsten Wiesel (1924-)


1
2
3
4A
4B
4C
5
6
1 mm


3
4A
4B
4Cα
4 Cβ
White matter
From LGN layer 1 (M)
From LGN layer 4,6 (P)
From LGN layer 2 (M)
From LGN layer 3,5 (P)
Contralateral eye column
Ipsilateral eye column

(A) Experimental setup

Light bar stimulus
projected on screen

Recording from visual cortex

Record

(B) Stimulus orientation

Stimulus presented

0 1 2 3

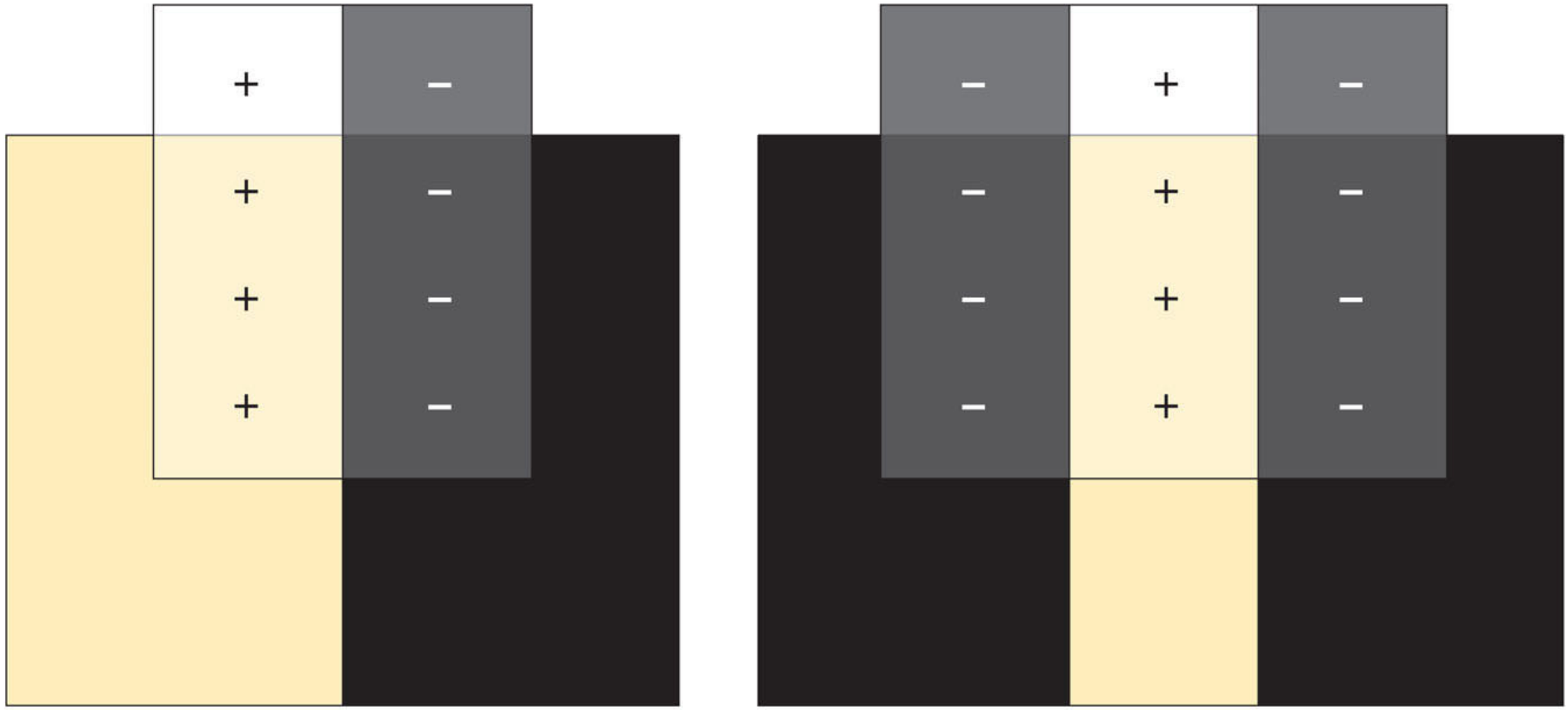
Time (s)

video

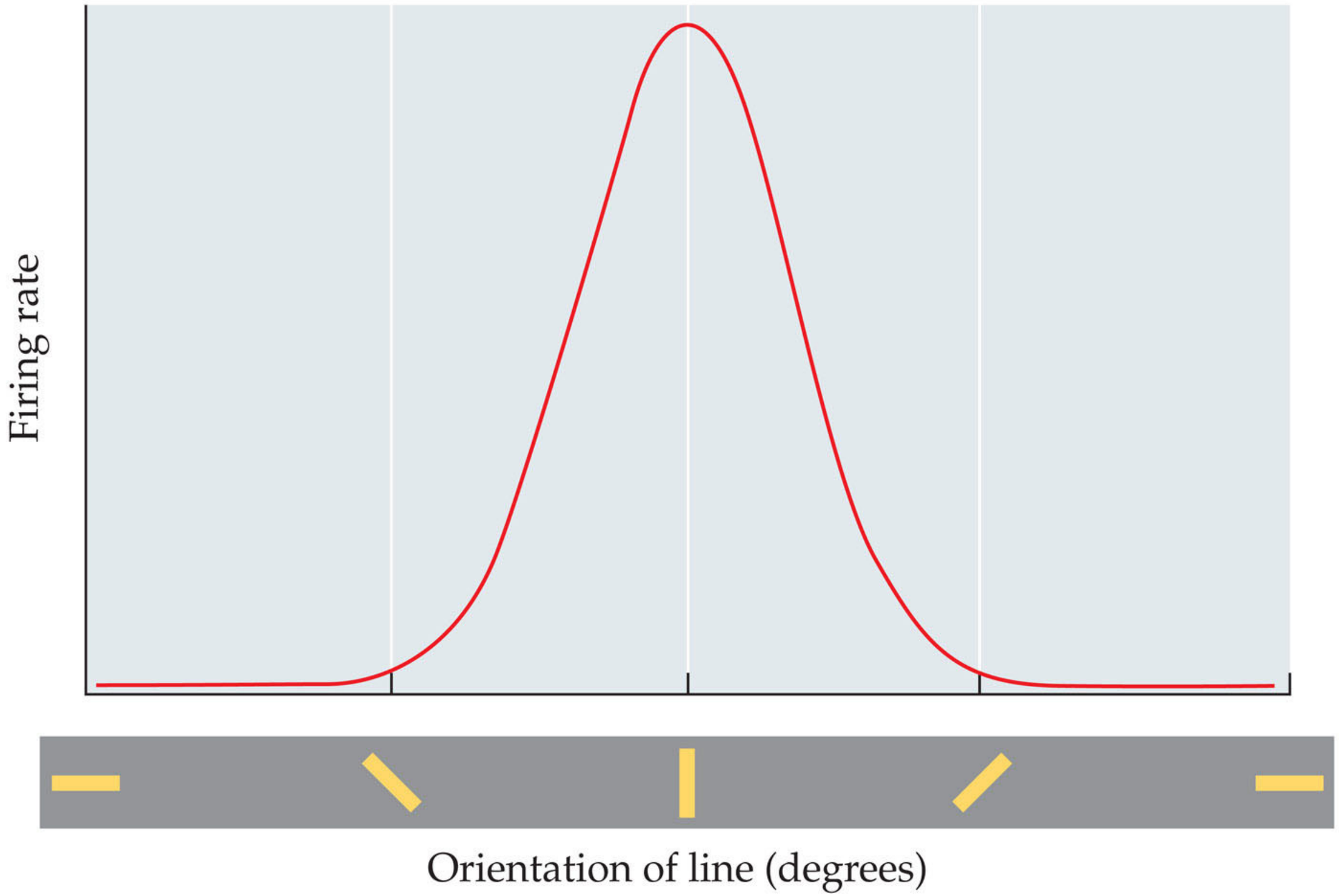
video

(*a*) Edge detector

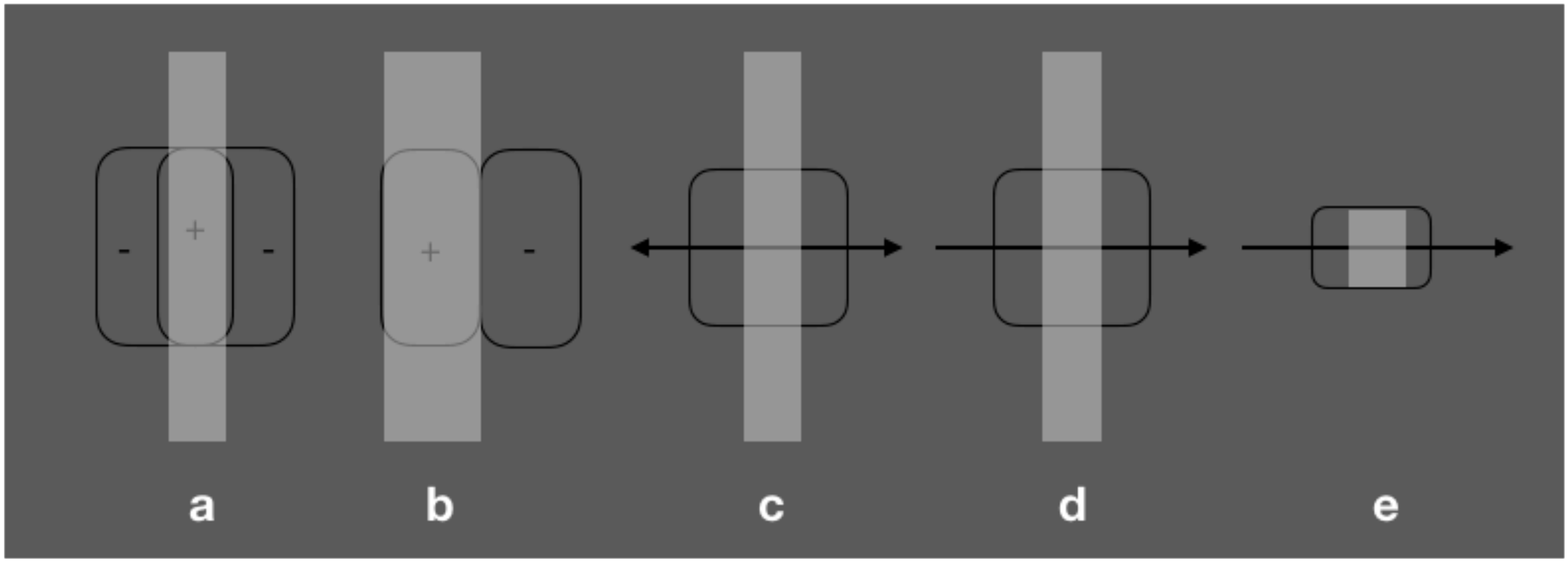
(*b*) Stripe detector



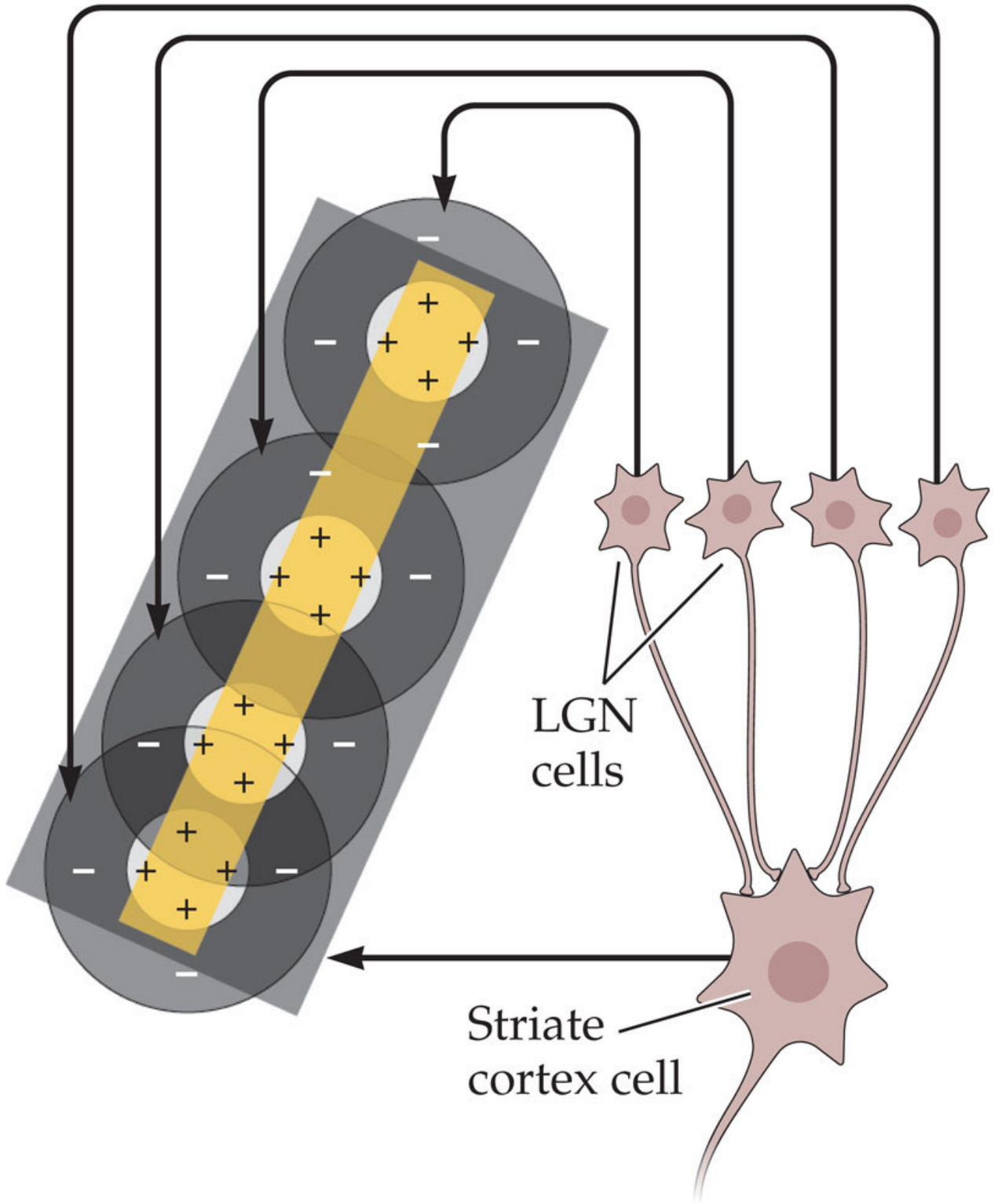
***SENSATION & PERCEPTION 4e,* Figure 3.23**



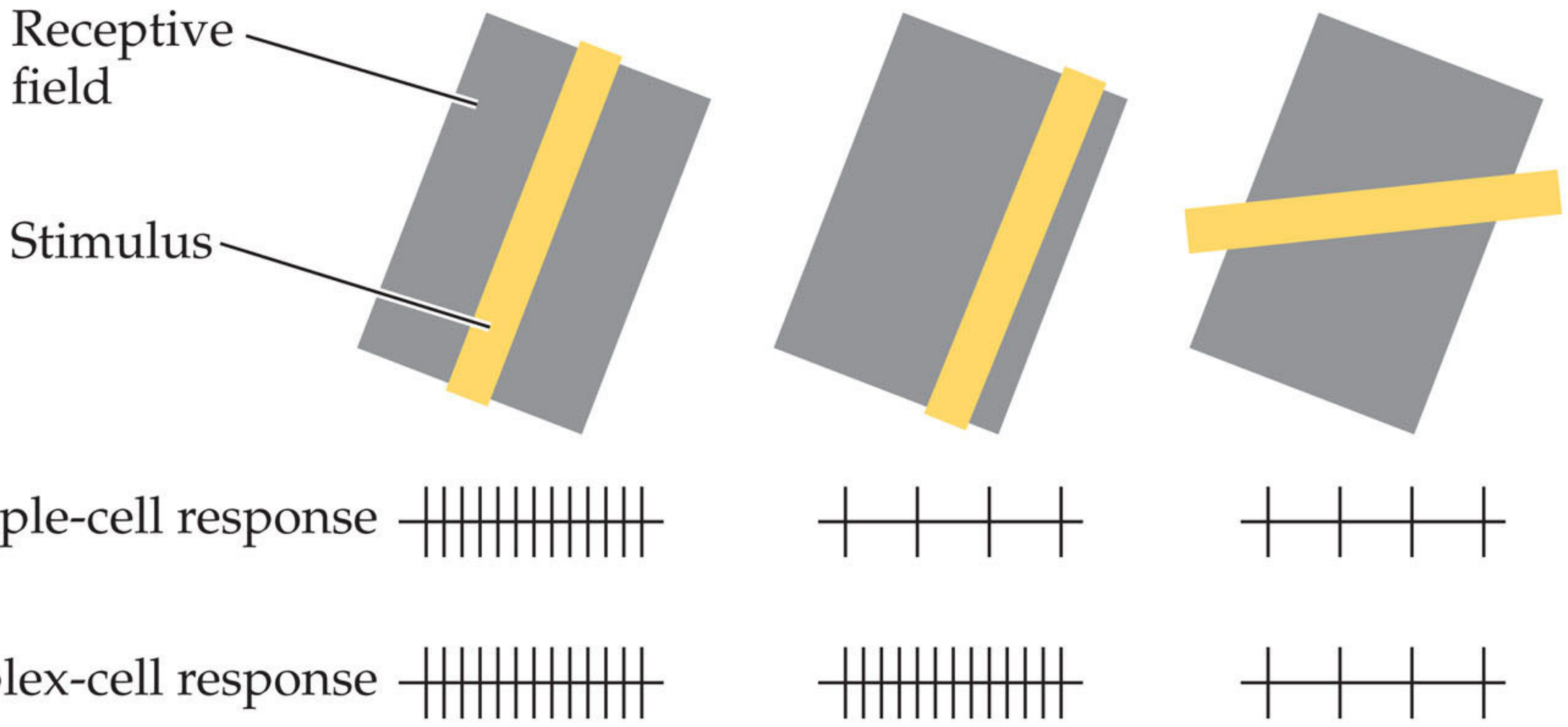
***SENSATION & PERCEPTION 4e,* Figure 3.21**



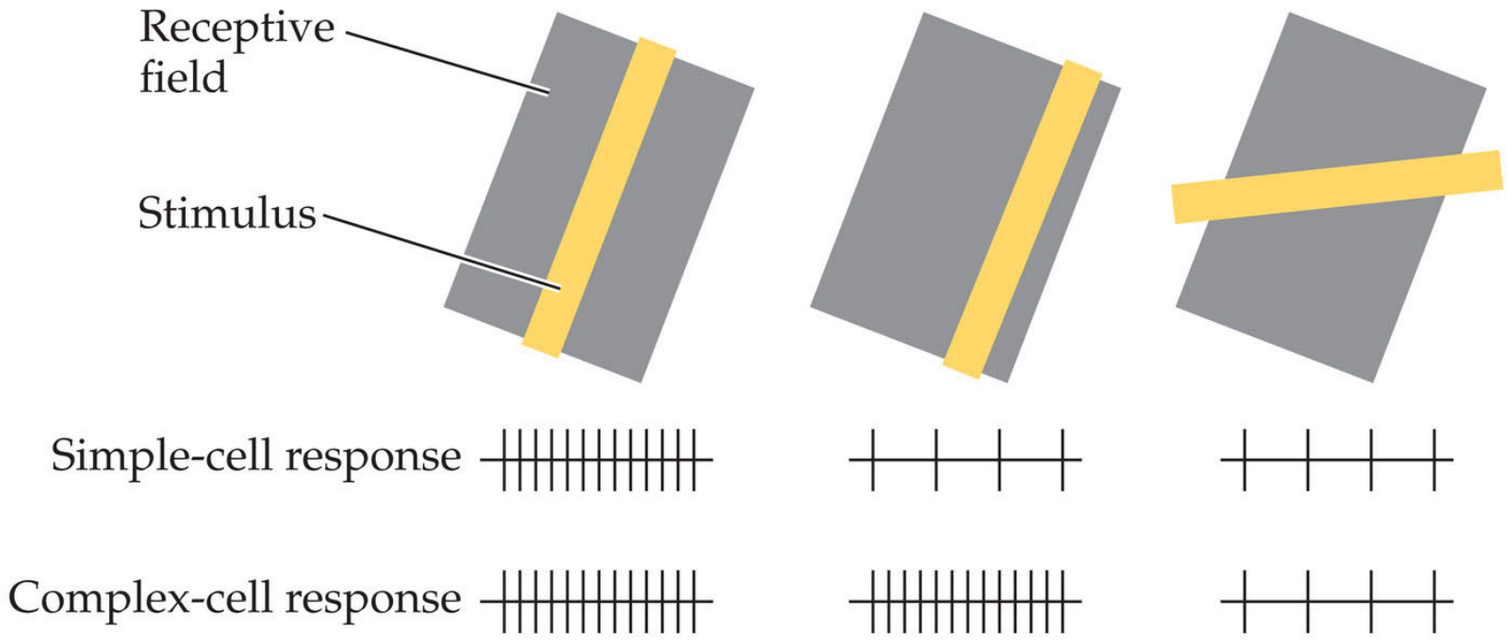
(a) e (b) semplice; (c) complesso non selettivo per la direzione; (d) complesso selettivo per la direzione; (e) ipercomplesso. Nel caso di (a) e (b) si osservano anche i campi recettivi complementari in cui l'effetto eccitatorio e inibitorio si scambiano di posto.



***SENSATION & PERCEPTION 4e*, Figure 3.22**

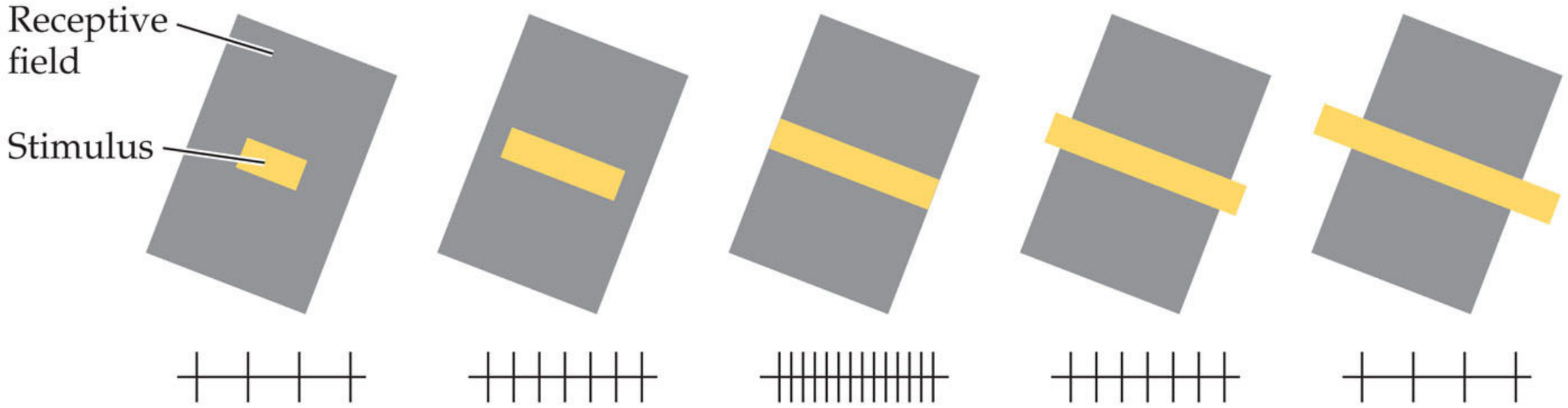


***SENSATION & PERCEPTION 4e*, Figure 3.24**

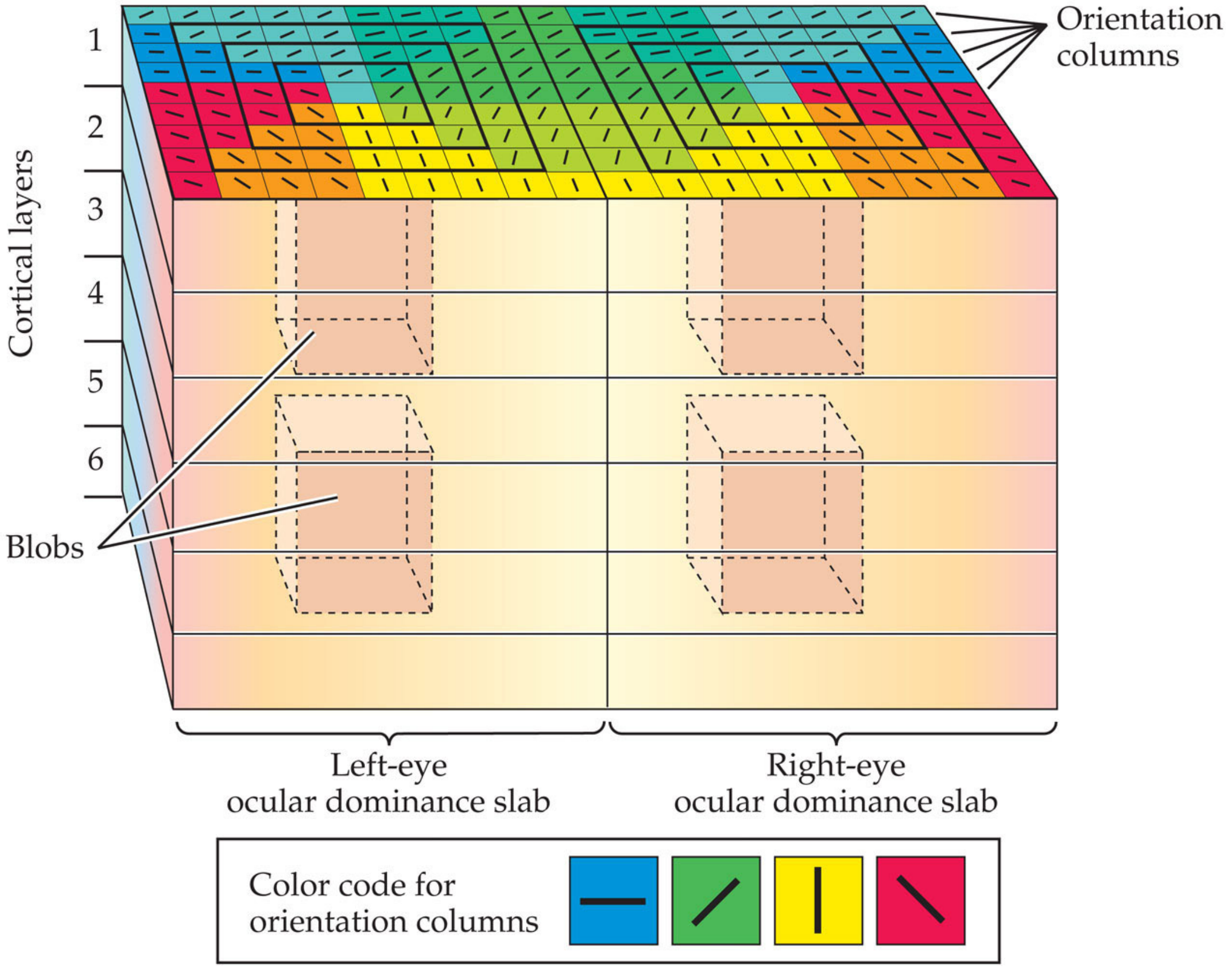


***SENSATION & PERCEPTION 4e,* Figure 3.24**

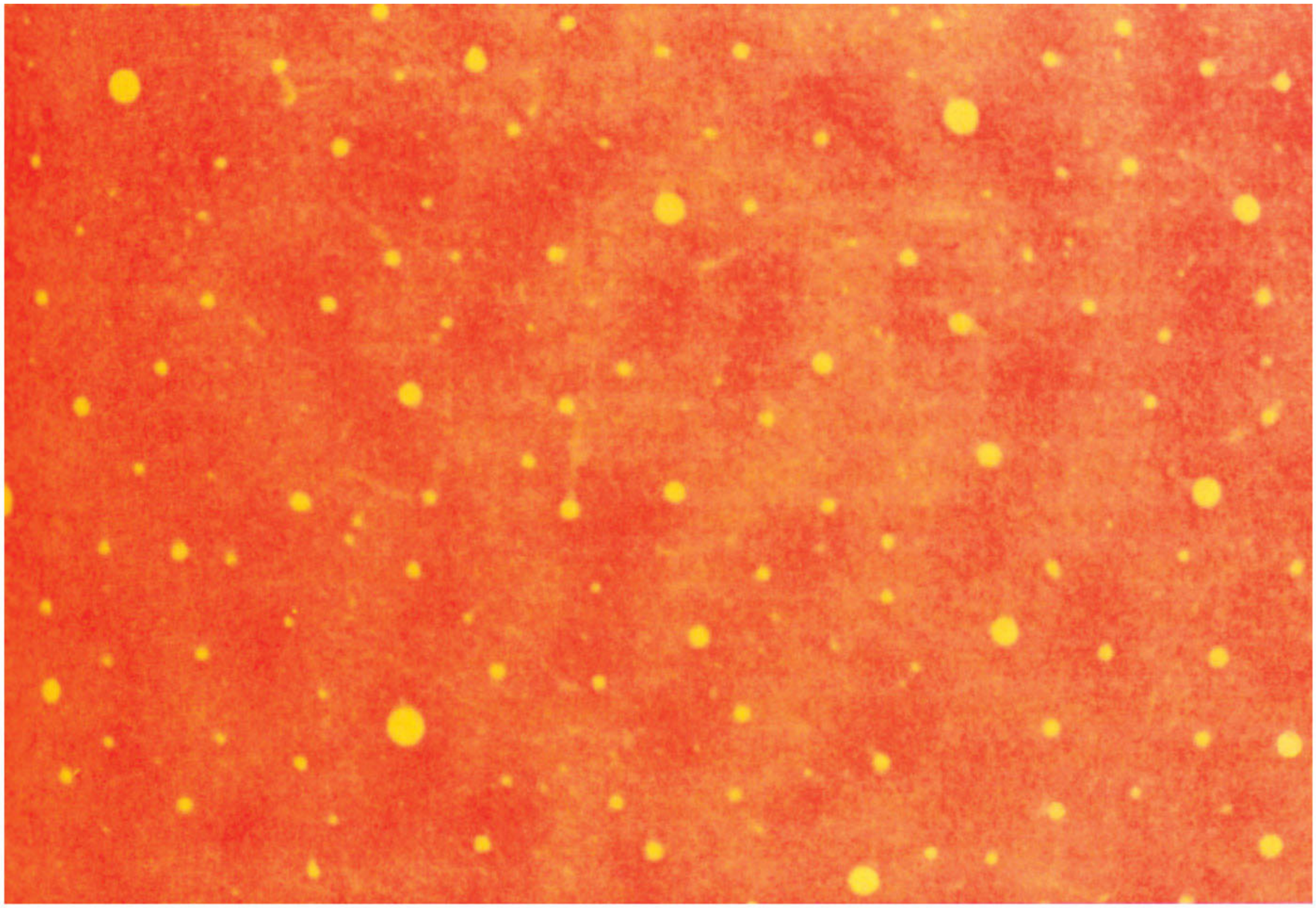
end stopping



***SENSATION & PERCEPTION 4e,* Figure 3.25**



***SENSATION & PERCEPTION 4e,* Figure 3.27**



***SENSATION & PERCEPTION 4e,* Figure 3.28**

from colums to pinwheels

from colums to pinwheels

in their studies from the 1950s and 60s, Hubel and Wiesel never directly observed a hypercolumn in toto

they inferred the existence of this structure from after−the−fact interpretation of the results of hundreds of experimental sessions

from colums to pinwheels

more recently, **optical imaging** methods have revealed that the functional organization of V1 is more complex

these methods exploit the fact that neural activity correlates with levels of hemoglobin

hemoglobin leves can be visualized by illuminating the cortical surface with long wavelenght light which is absorbed more by more active regions

Illuminator

Video camera

Macro lens

Optical chamber

Visual stimulation computer

Imaging computer

Data display

Monitor

from colums to pinwheels

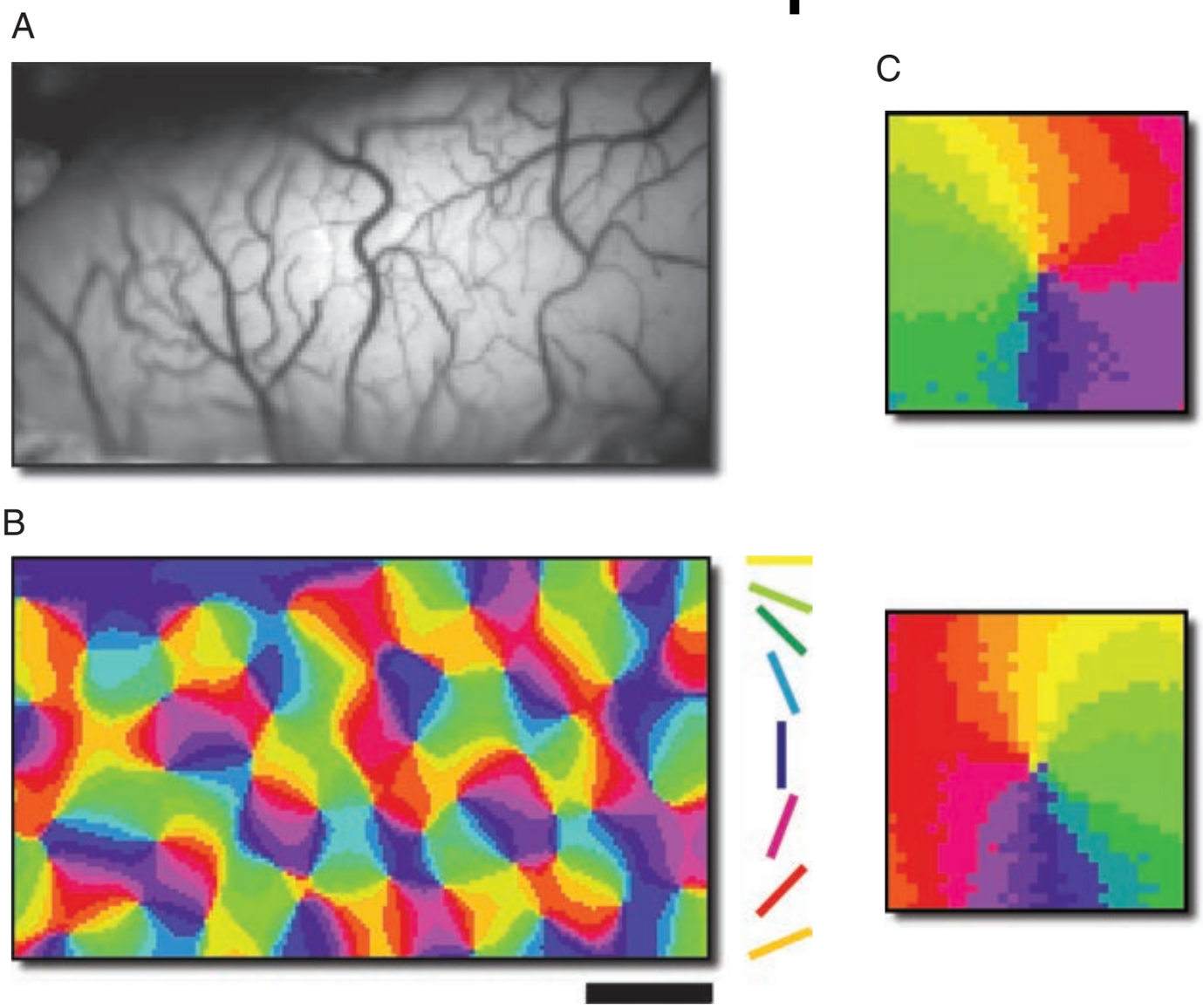
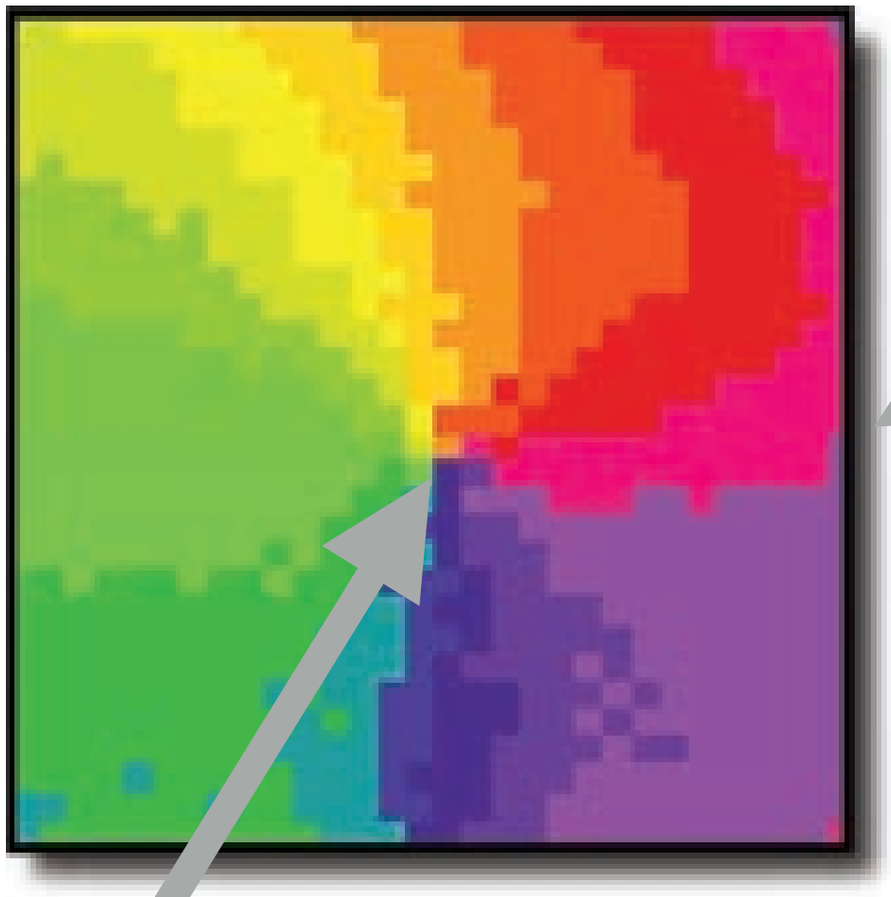


FIGURE 3.4 The organization of visual cortex in the cat, assessed with optical imaging of intrinsic signals. Panel **A** illustrates the surface of the cortex from which the subsequent images were acquired (scale bar = 1 mm). **B.** Map of preferred orientations in the region illustrated in **A**, color-coded to indicate which of the 8 orientations shown on the right-hand side of the figure produced the maximal response at each location. The panels in **C** are close-up images (for these two panels, the scale bar from **B** corresponds to 300 μm) of the centers of two of the pinwheels seen in **B.** Note the smooth transitions from one preferred orientation to the next within each pinwheel.
Source: Image courtesy of Tobias Bonhoeffer, based on Bonhoeffer and Grinvald, 1991. Reproduced with permission of Nature Publishing Group.

anatomy of a pinwheel



"petals" containing orientation-selective columns

orientation- insensitive central blob

Lezione 24-25

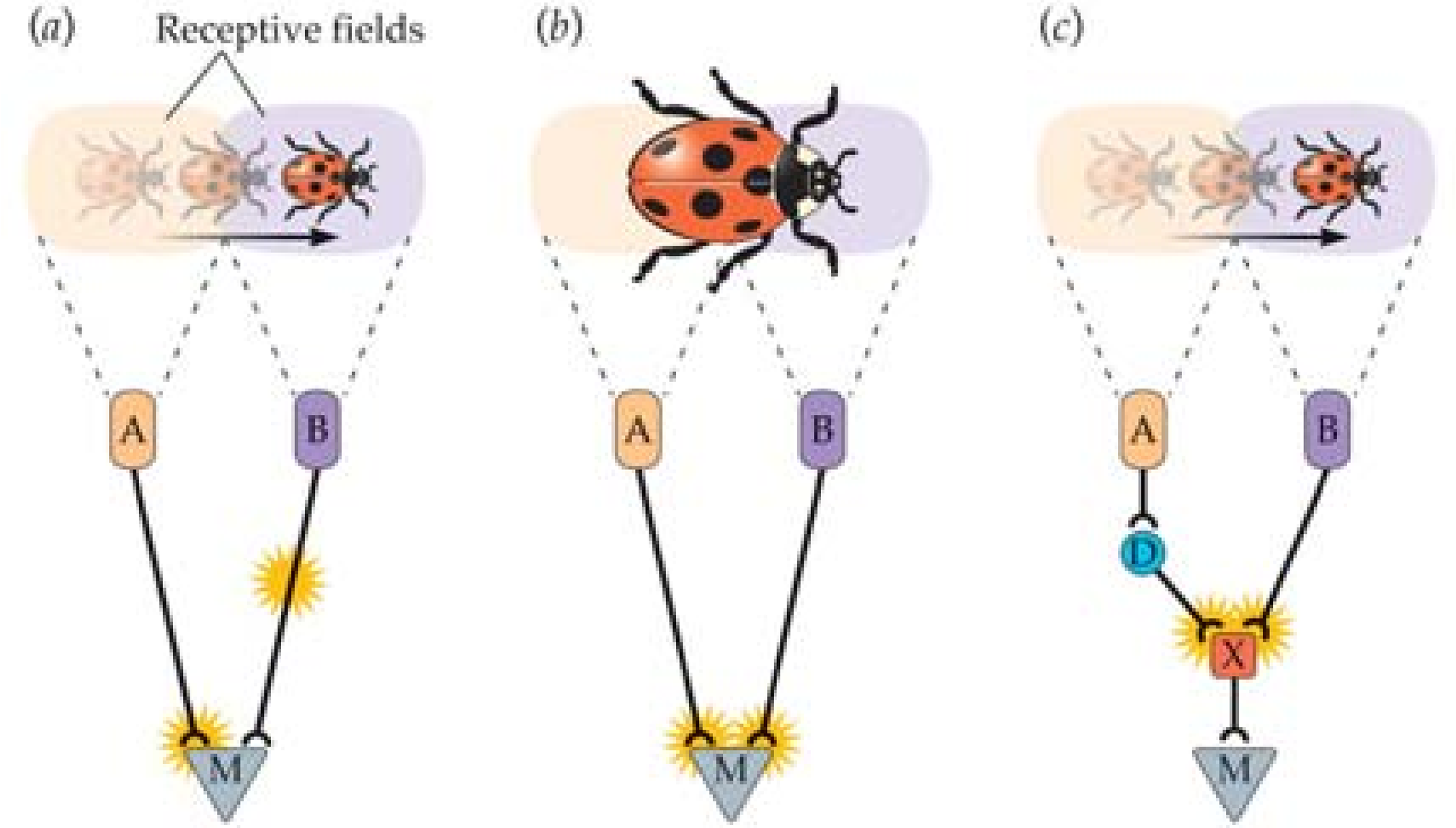
visione di basso livello: contrasto, frequenza spaziale, orientazione e movimento locale

video

Time 1

Time 2

movimento = cambio di posizione nel tempo


(a)
Receptive fields
A
B
M
(b)
A
B
M
(c)
A
B
D
X
M

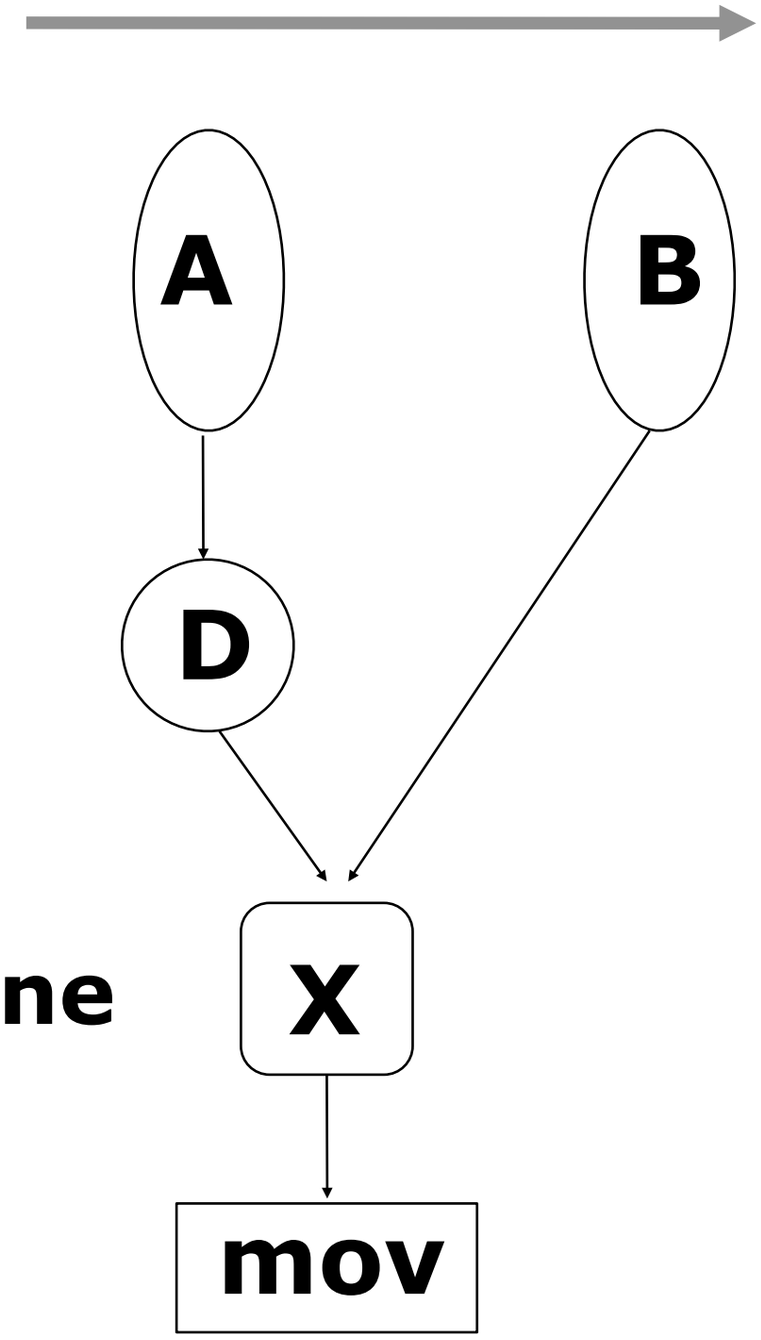
rilevatori di movimento

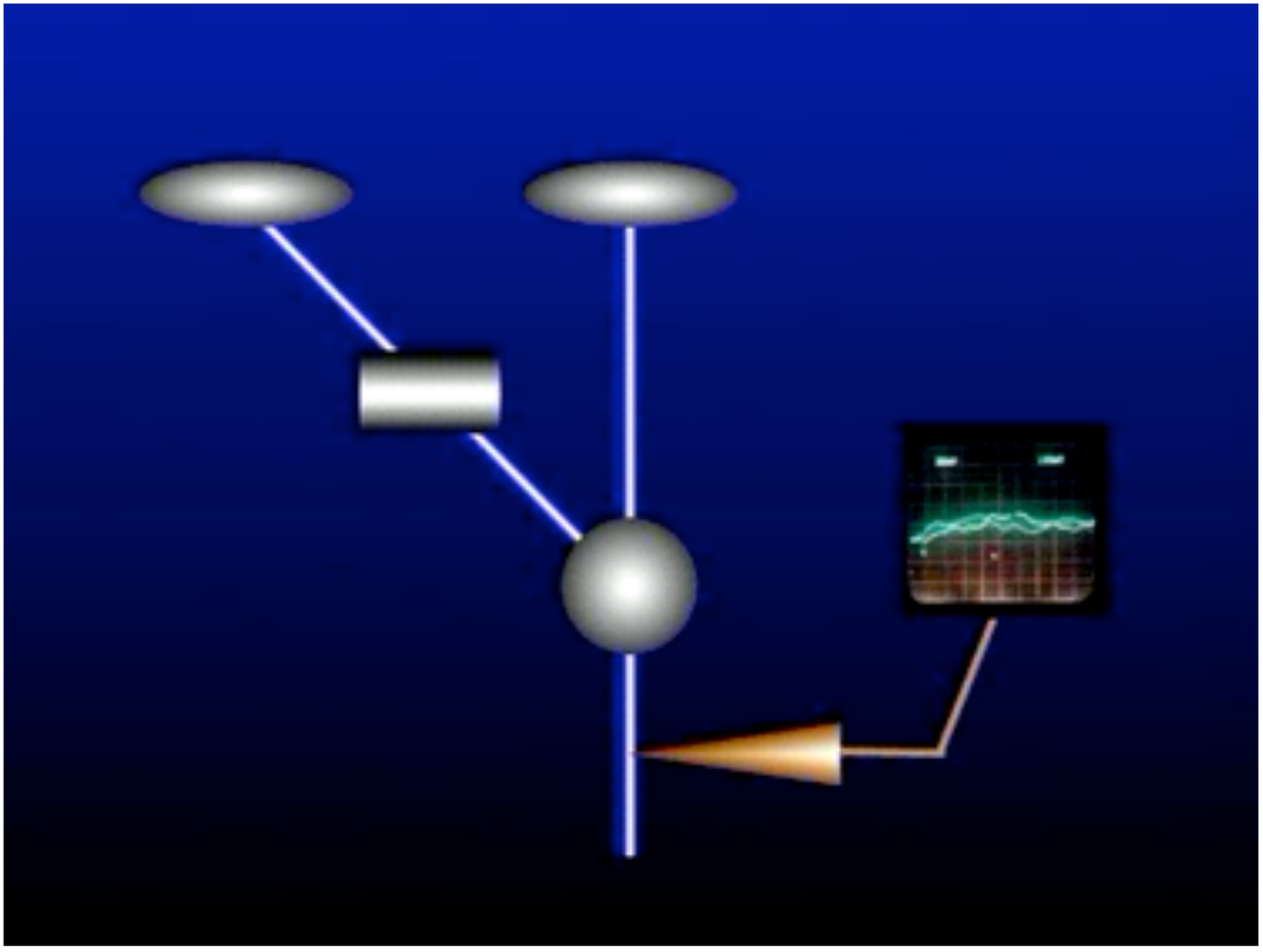
direz. movimento

due neuroni

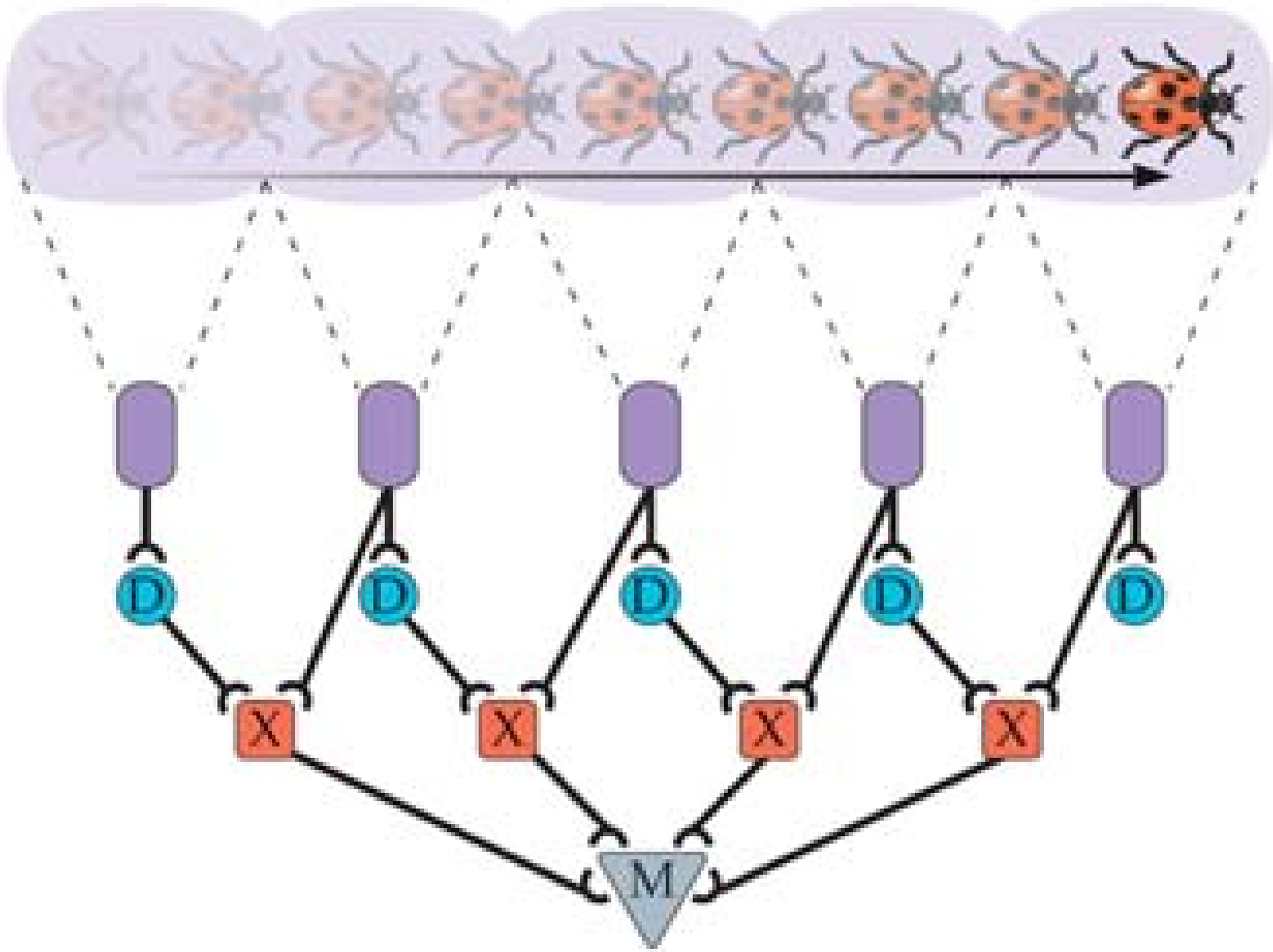
ritardo

moltiplicazione





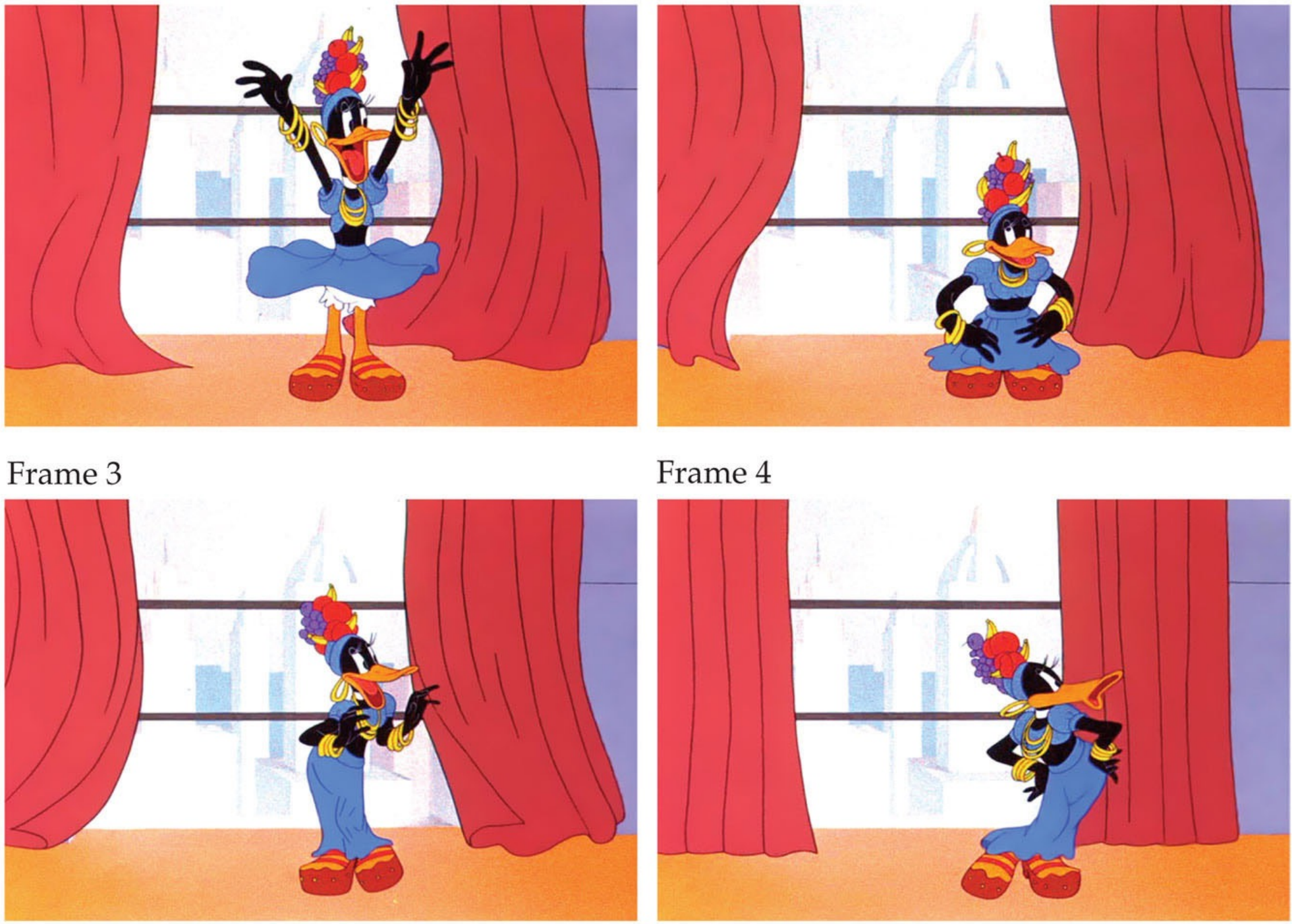
(*d*)



rilevatore di Reichardt

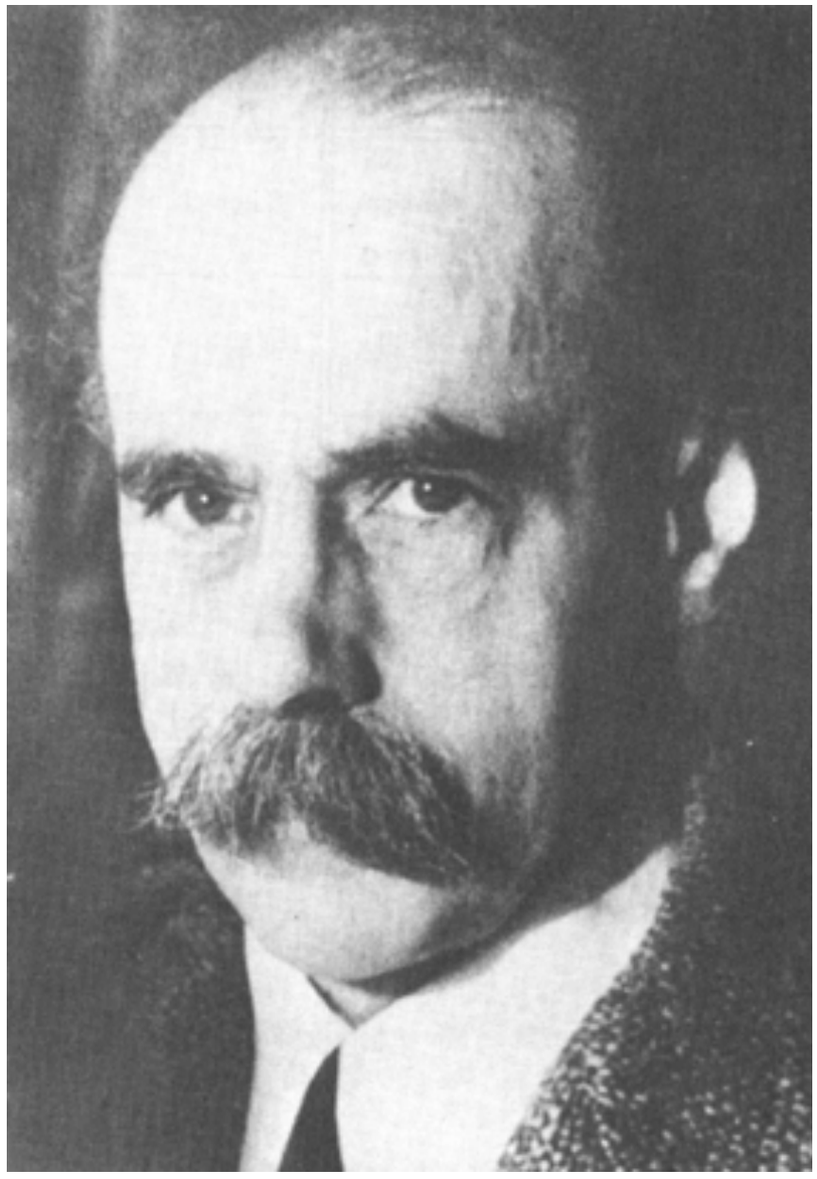
selettivo per la direzione
selettivo per la velocità
prevede il *movimento stroboscopico*
prevede *aftereffect* di movimento

movimento stroboscopico ("apparente")



***SENSATION & PERCEPTION 4e,* Figure 8.4**

illusione della cascata

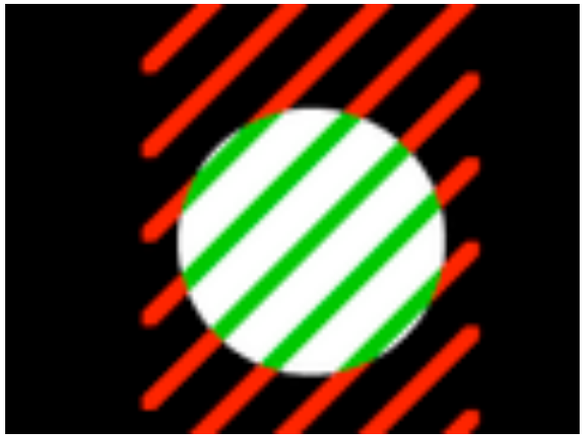


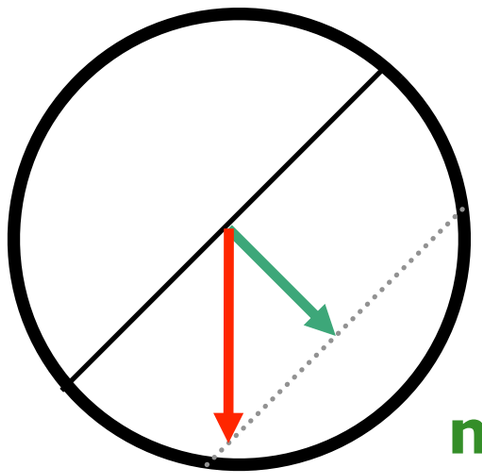
Max Wertheimer (1880-1943)

il fenomeno *phi*

FIGURA 74. I quattro fotogrammi di una semplice animazione che consente di osservare il fenomeno phi (i fotogrammi vanno ripetuti in un ciclo continuo). Ogni fotogramma va presentato per 50 millisecondi. Pertanto ogni rettangolo dura 150 millisecondi in totale, ma il rettangolo di destra appare 100 millisecondi dopo la compara di quello di sinistra, e viceversa. L'SOA è quindi di 100 millisecondi; l'ISI (differenza fra il tempo in cui appare il secondo e il tempo in cui scompare il primo) è di -50 millisecondi.

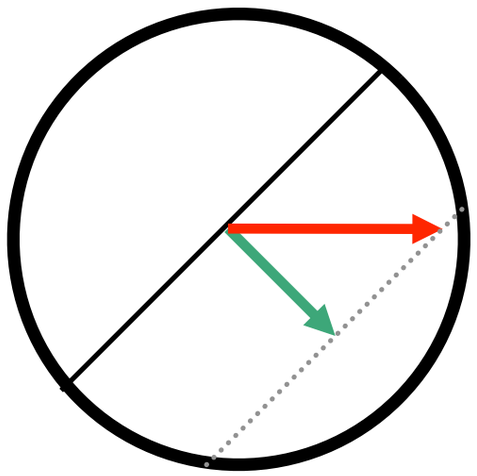
problema dell'apertura





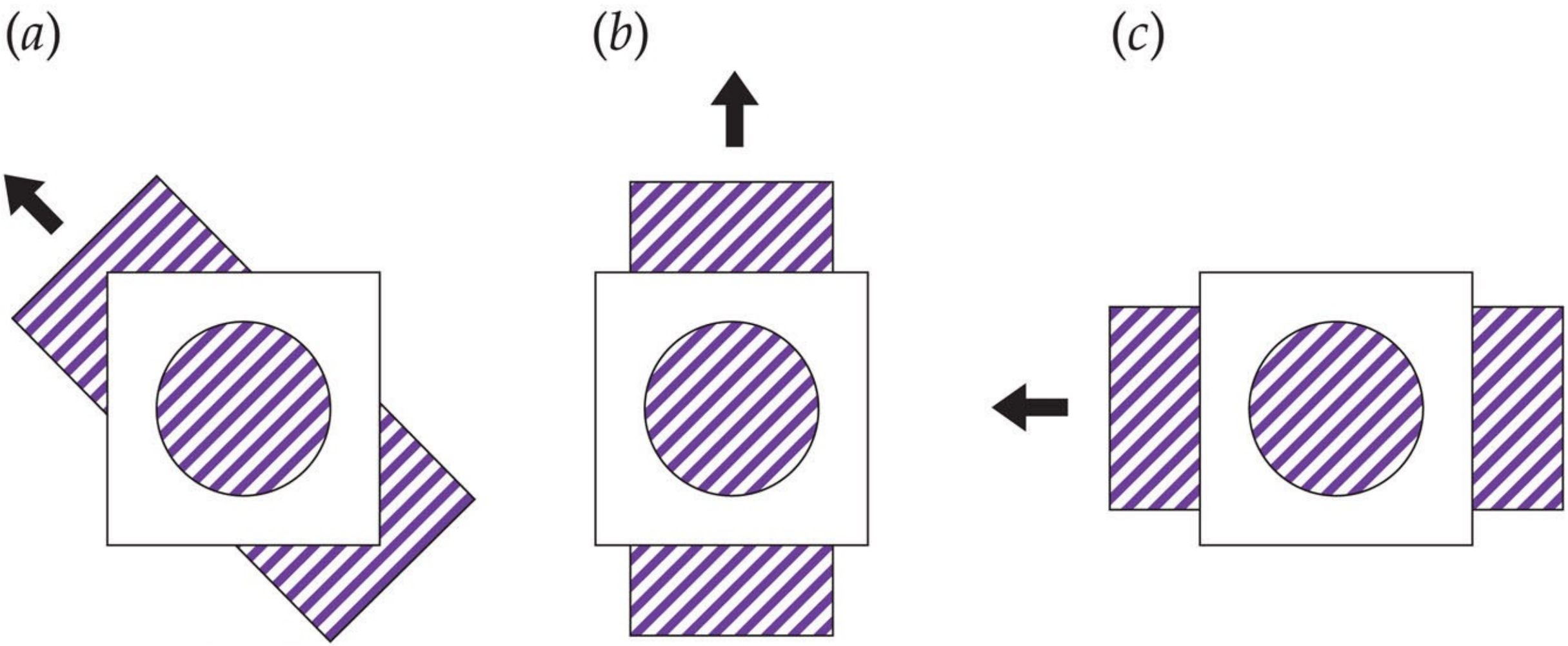
movimento "reale"

movimento codificato dal rilevatore di Reichardt

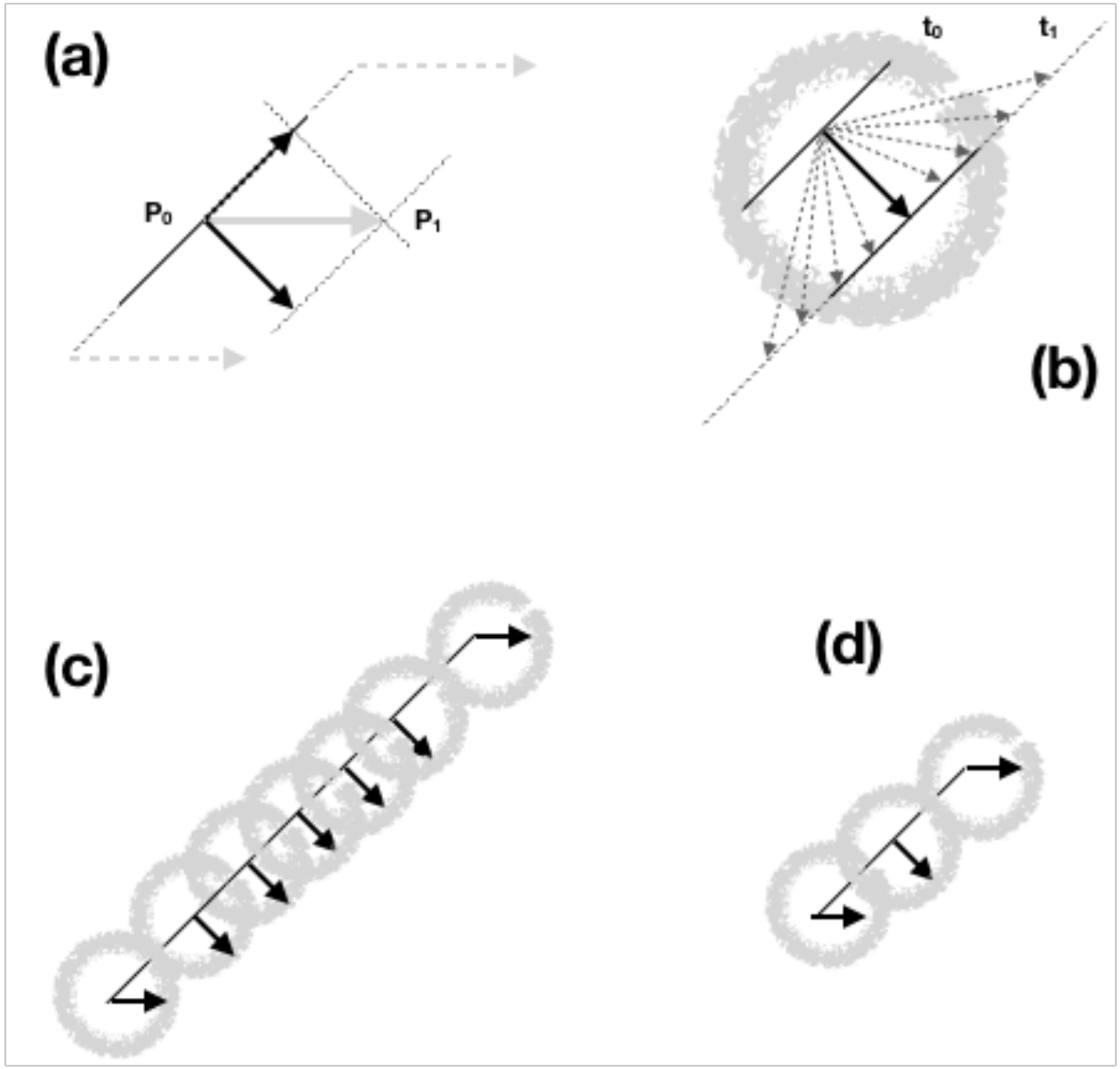


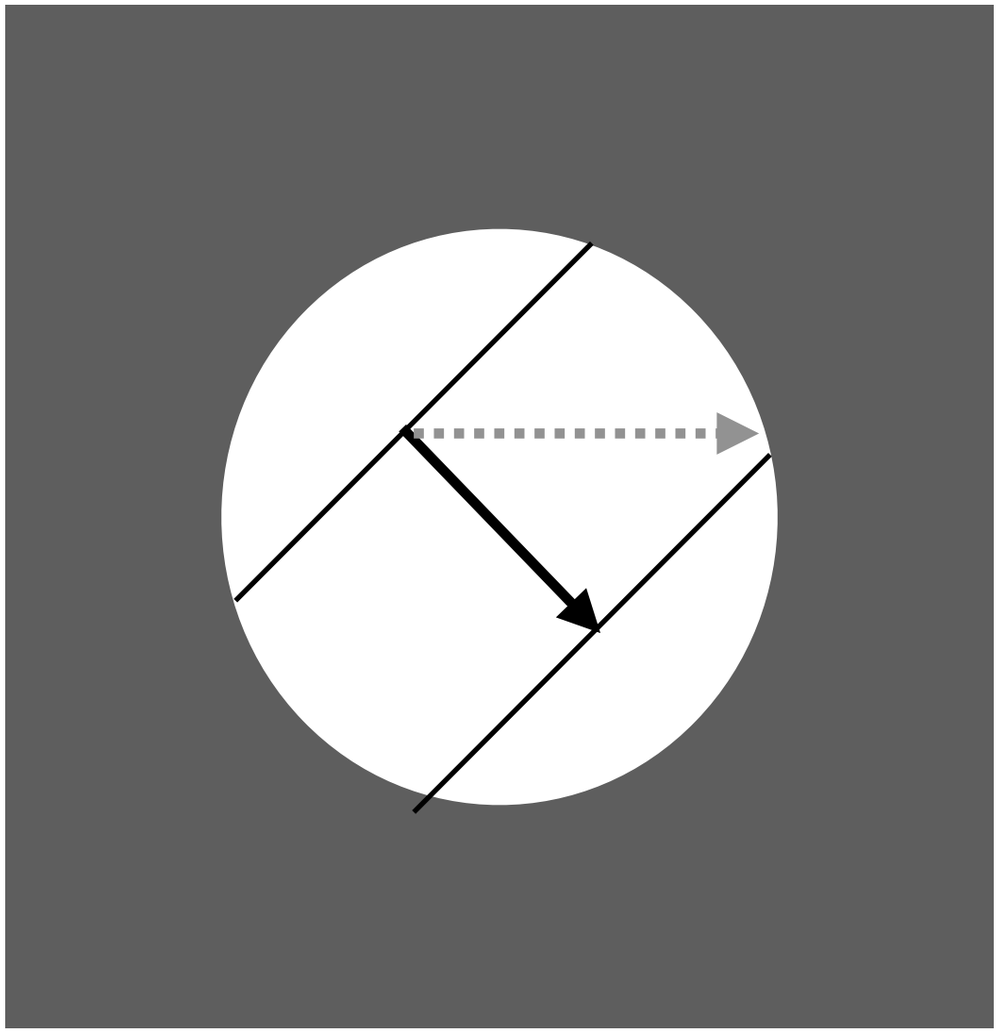
movimento "reale"

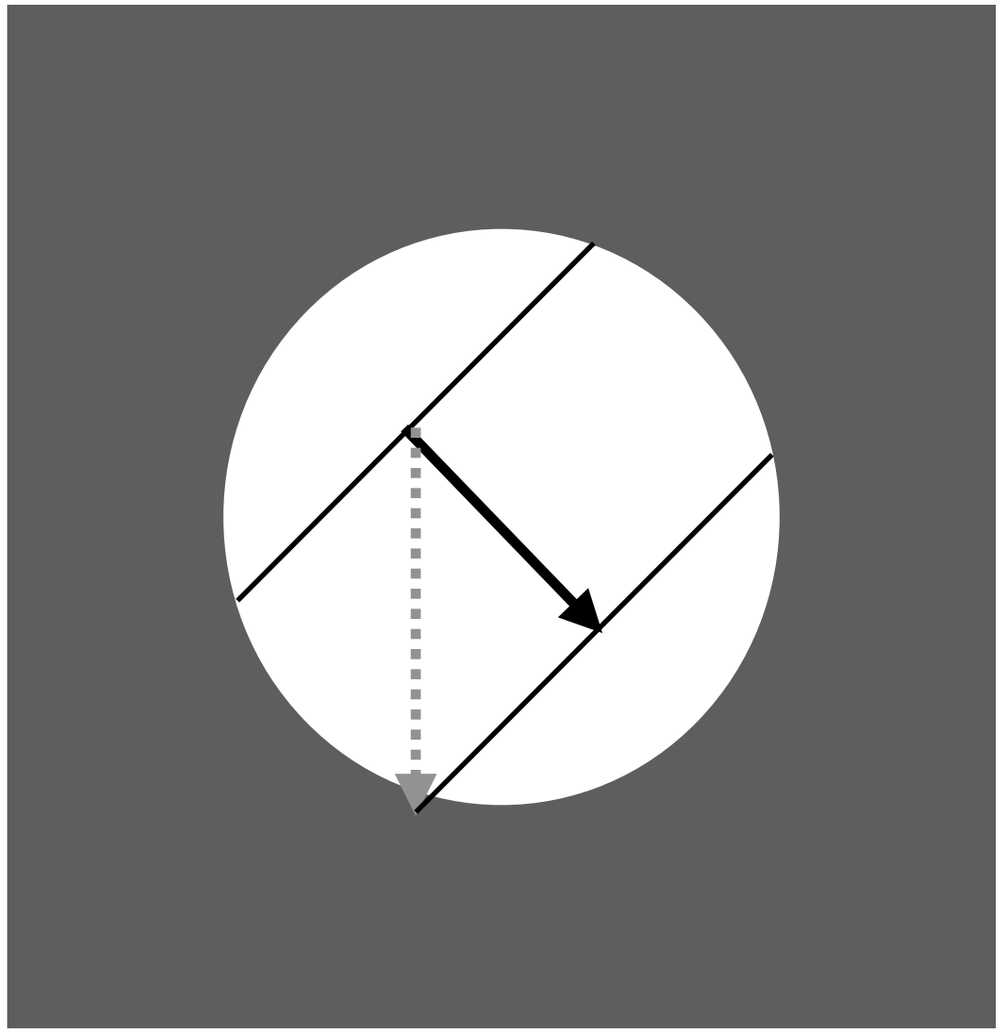
Figure 8.6 The aperture problem



***SENSATION & PERCEPTION 4e*, Figure 8.6**


(a)
P0
P1
t0
t1
(b)
(c)
(d)

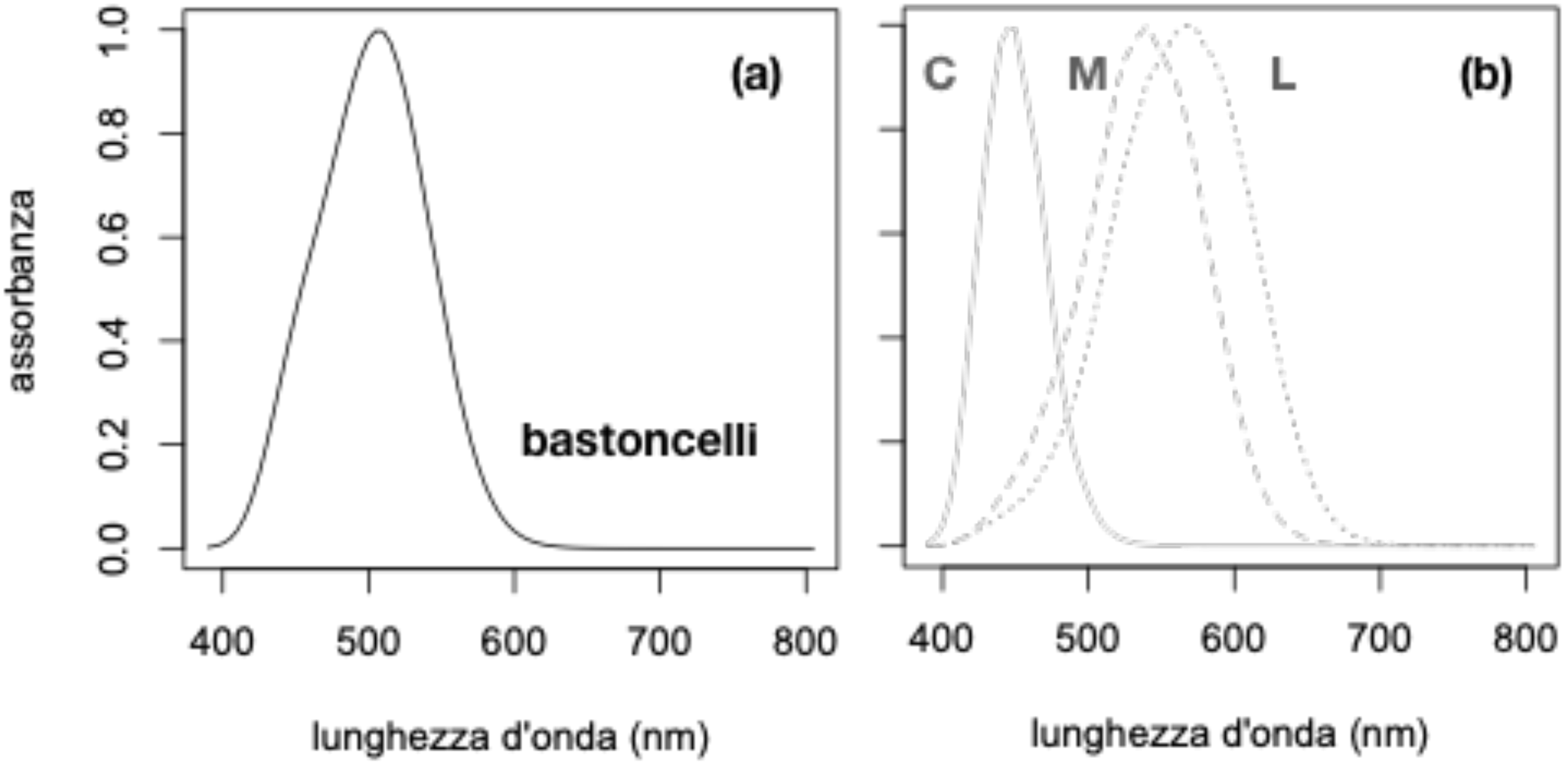


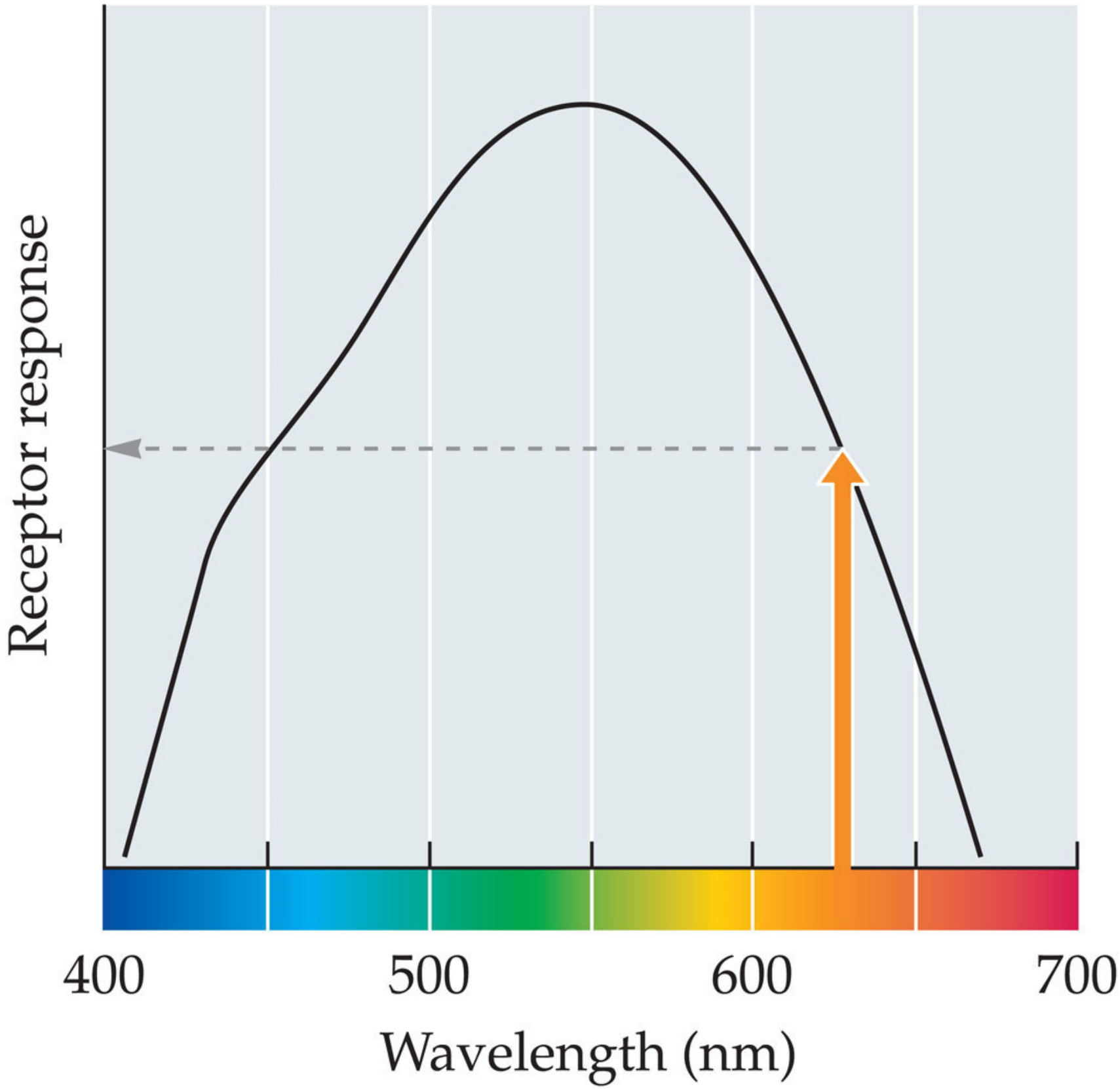


Lezione 26-27

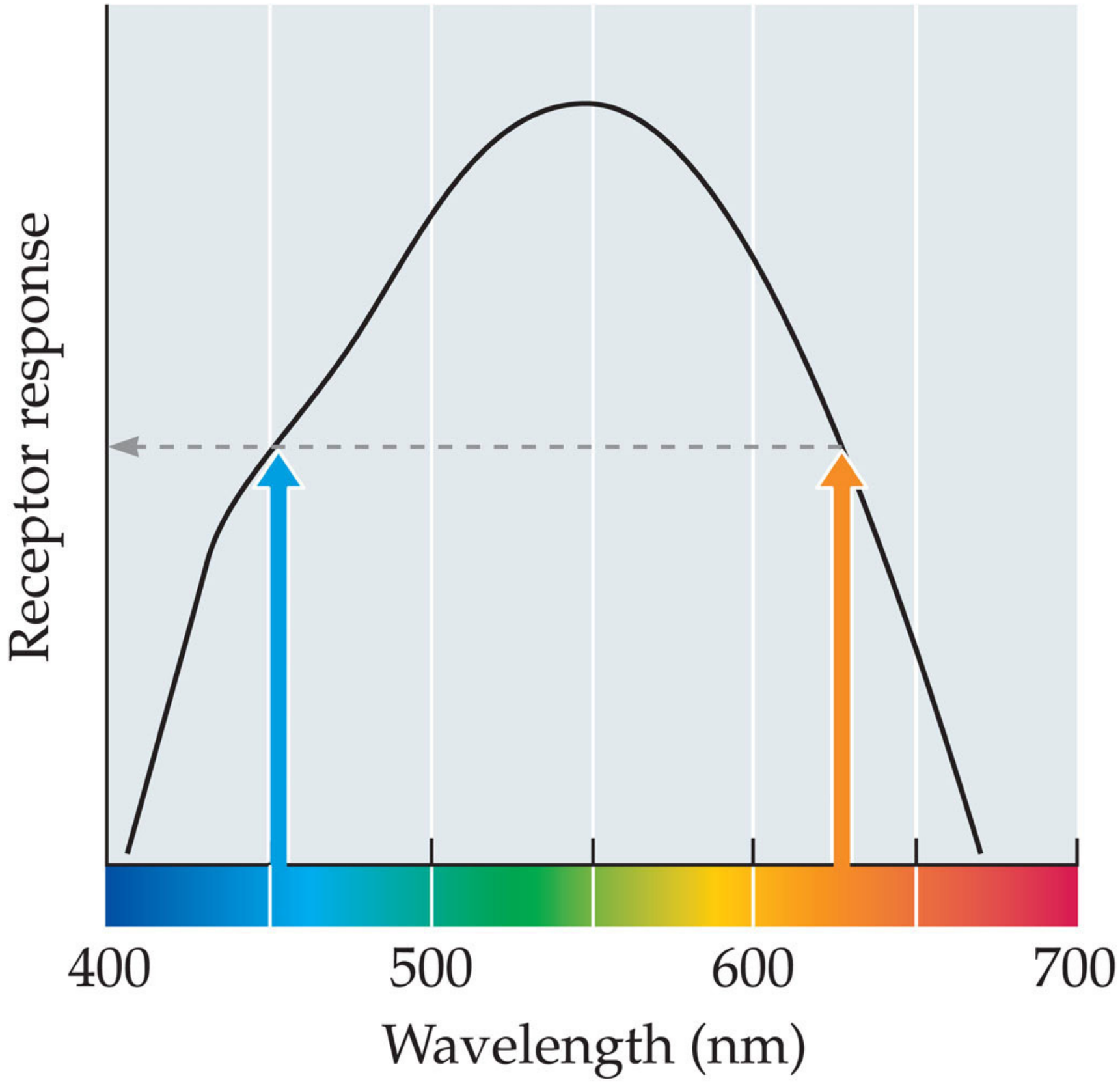
visione di basso livello: contrasto cromatico

di notte non si vedono i colori, perché?

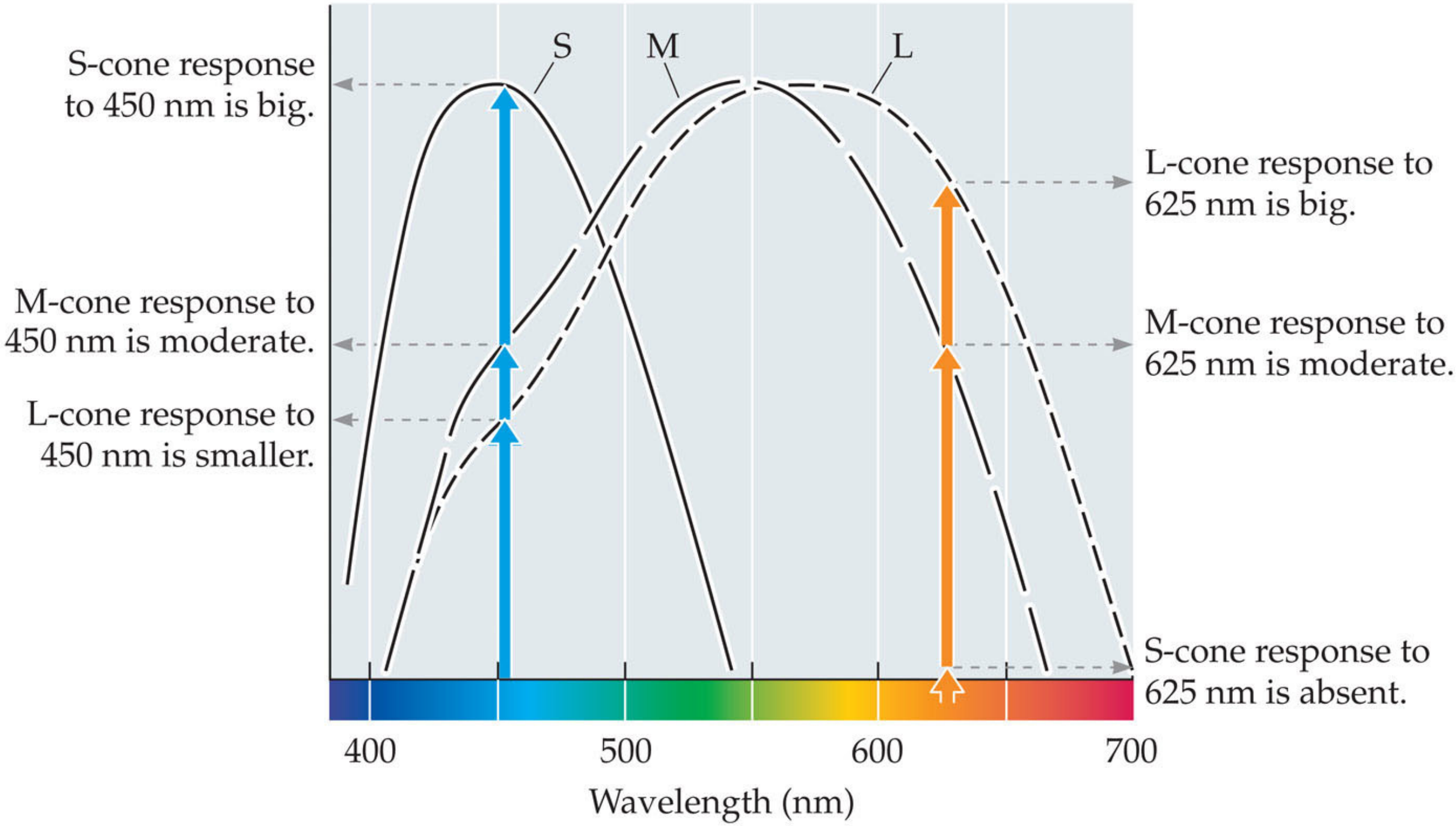




***SENSATION & PERCEPTION 4e*, Figure 5.2**



***SENSATION & PERCEPTION 4e,* Figure 5.3**

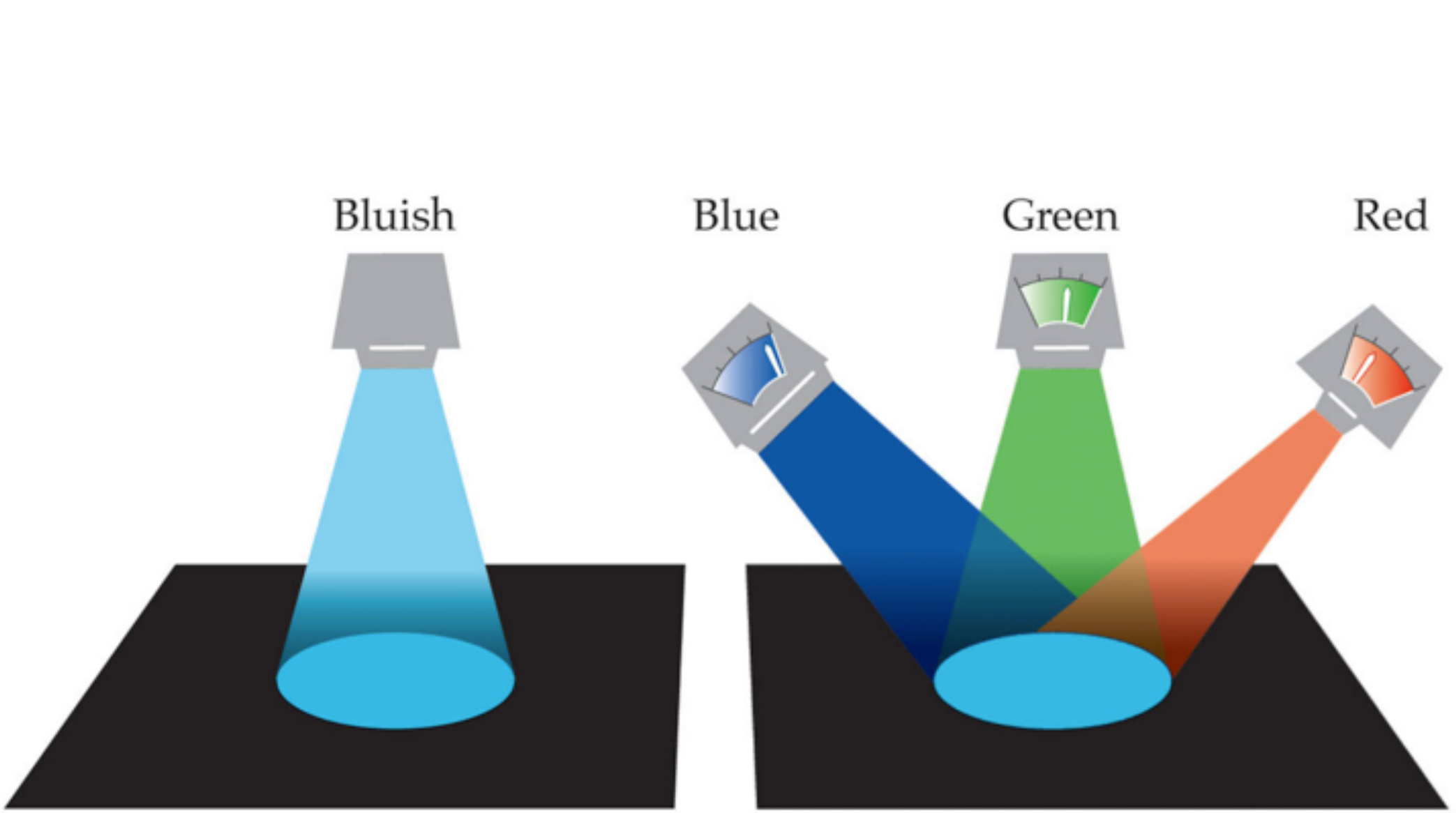


***SENSATION & PERCEPTION 4e,* Figure 5.5**

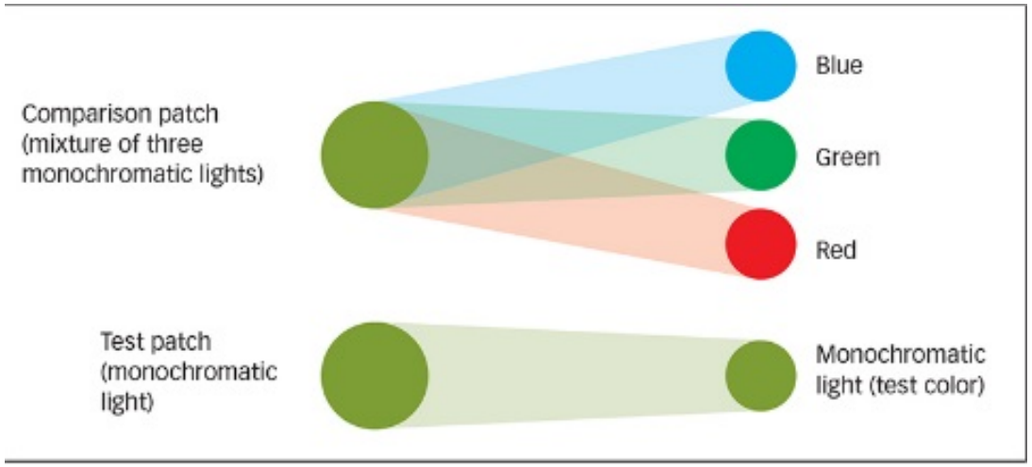
tricromaticità

Thomas Young (1773–1829)

Hermann von Helmholtz (1821–1894)



SENSATION AND PERCEPTION, **Figure 5.11**



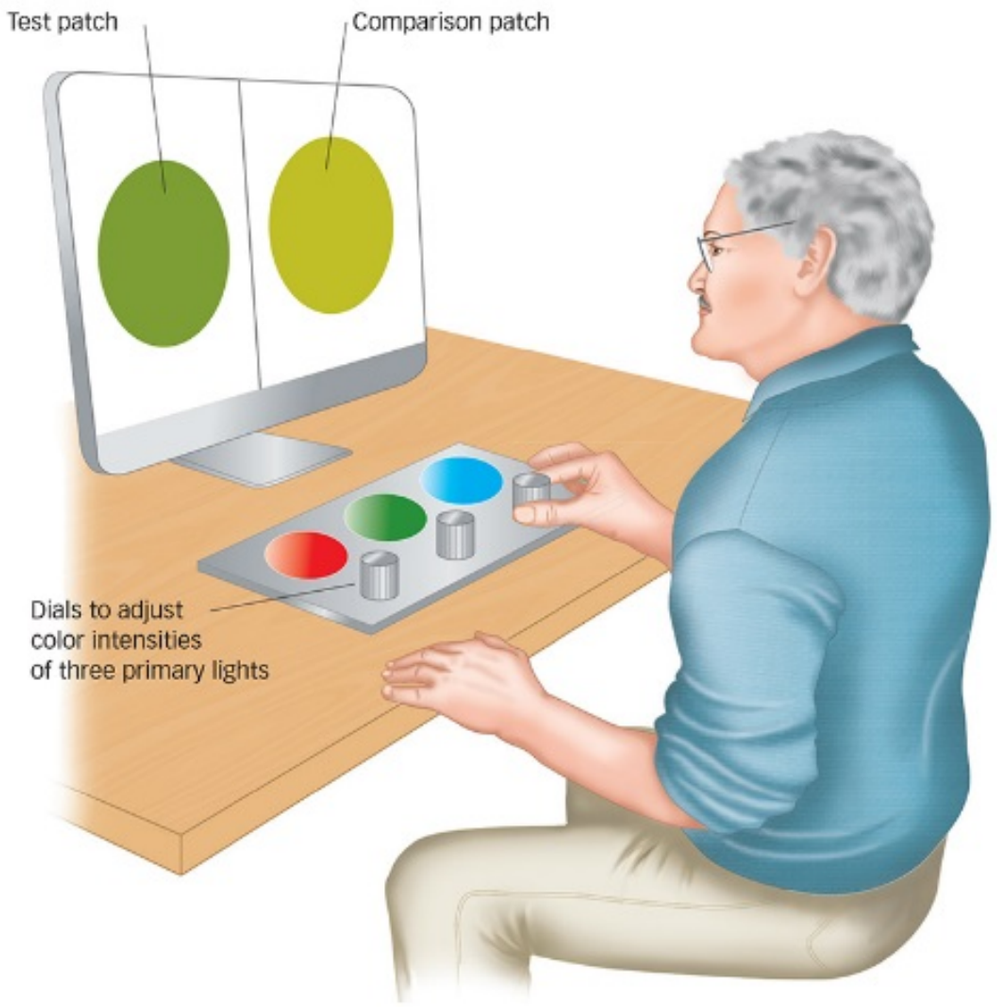


FIGURE 6.12 Metameric Matching

The participant in a metameric matching study is shown a test patch of monochromatic light. The participant has control over three primary lights in the comparison patch. He must adjust the intensity of each of the primary lights until the mix of the three lights looks subjectively identical to the monochromatic test patch.

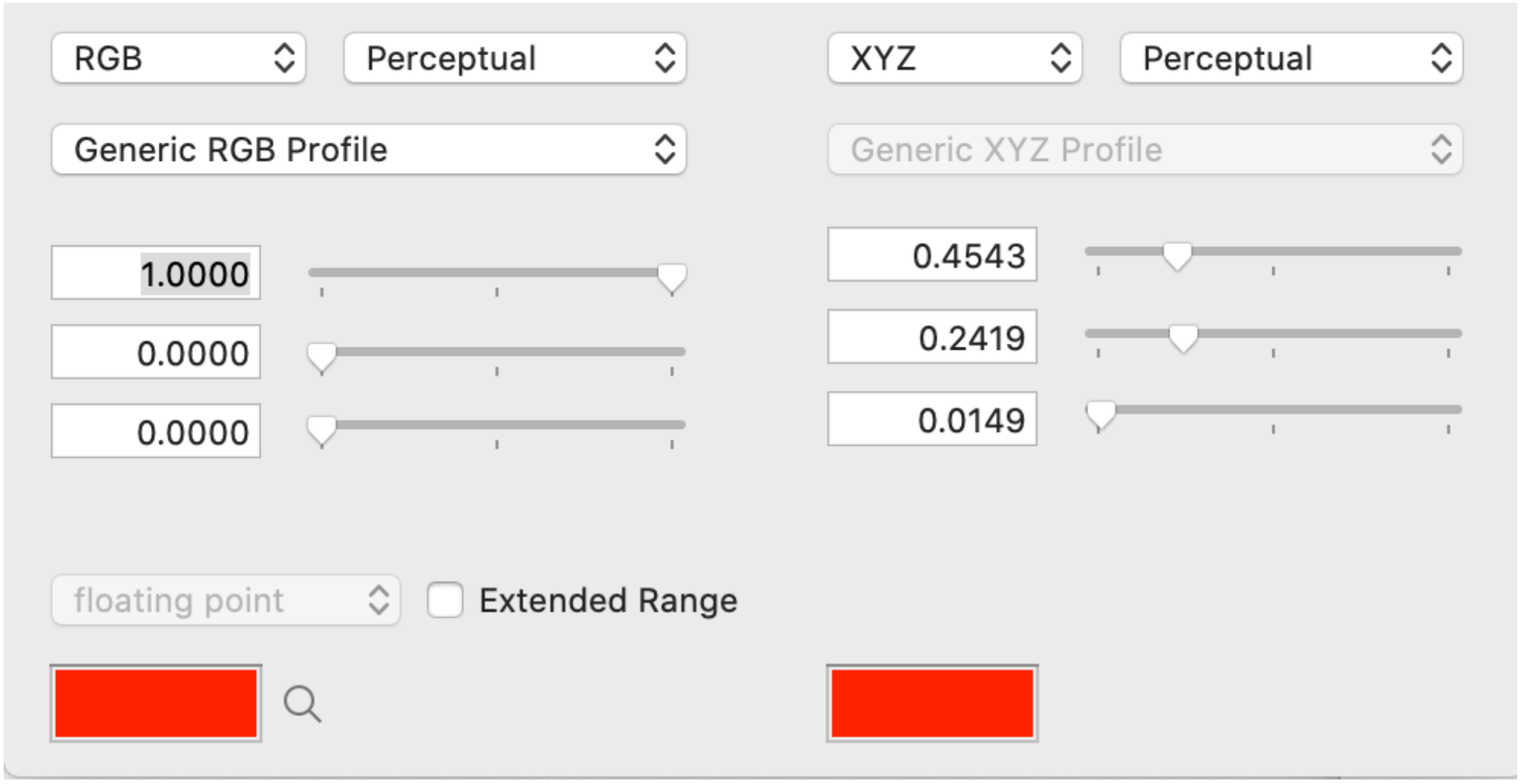
CIE

spazio dei colori XYZ CIE 1931

derivato da esperimenti di uguagliamento svolti negli anni `20

modello per predire il metamerismo

XYZ = valori tristimolo = proporzione di tre "colori primari" teorici necessaria a uguagliare un "colore" test

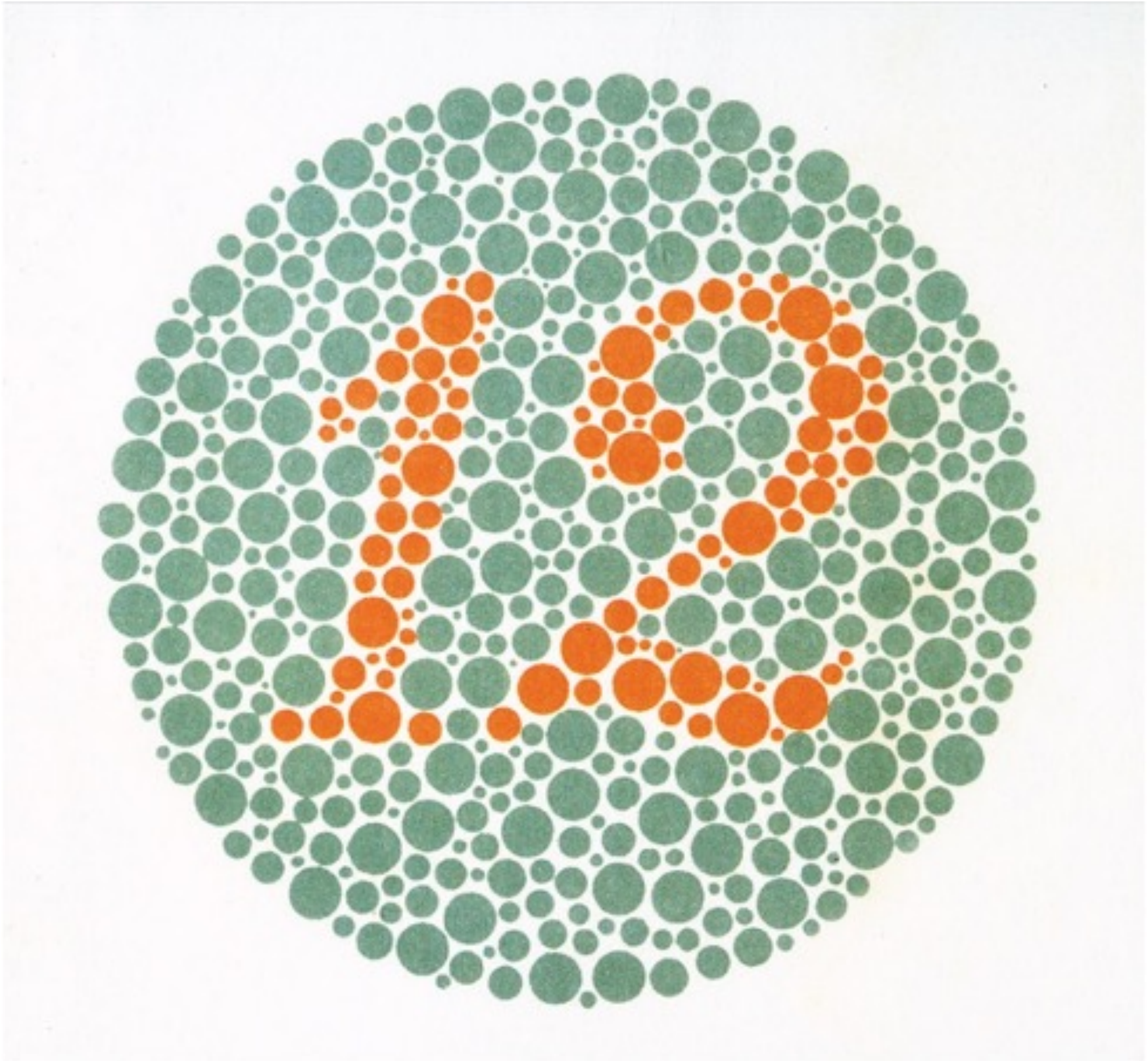

RGB
Perceptual
XYZ
Perceptual
Generic RGB Profile
Generic XYZ Profile
1.0000
0.0000
0.4543
0.2419
0.0149
floating point
Extended Range

***SENSATION & PERCEPTION 4e*, Figure 5.11**

"daltonismo"

8% degli uomini e raro nelle donne
geni per i fotopigmenti M e L nel cromosoma X

deuteranopia: (5% incluso Dalton)
assenza dei coni M
protanopia: (1%) assenza dei coni L
tritanopia: (0.005%) assenza dei coni S (rara)
tricromaticità anomala
monocromia dei coni (rarissima)
monocromia dei bastoncelli (rarissima)



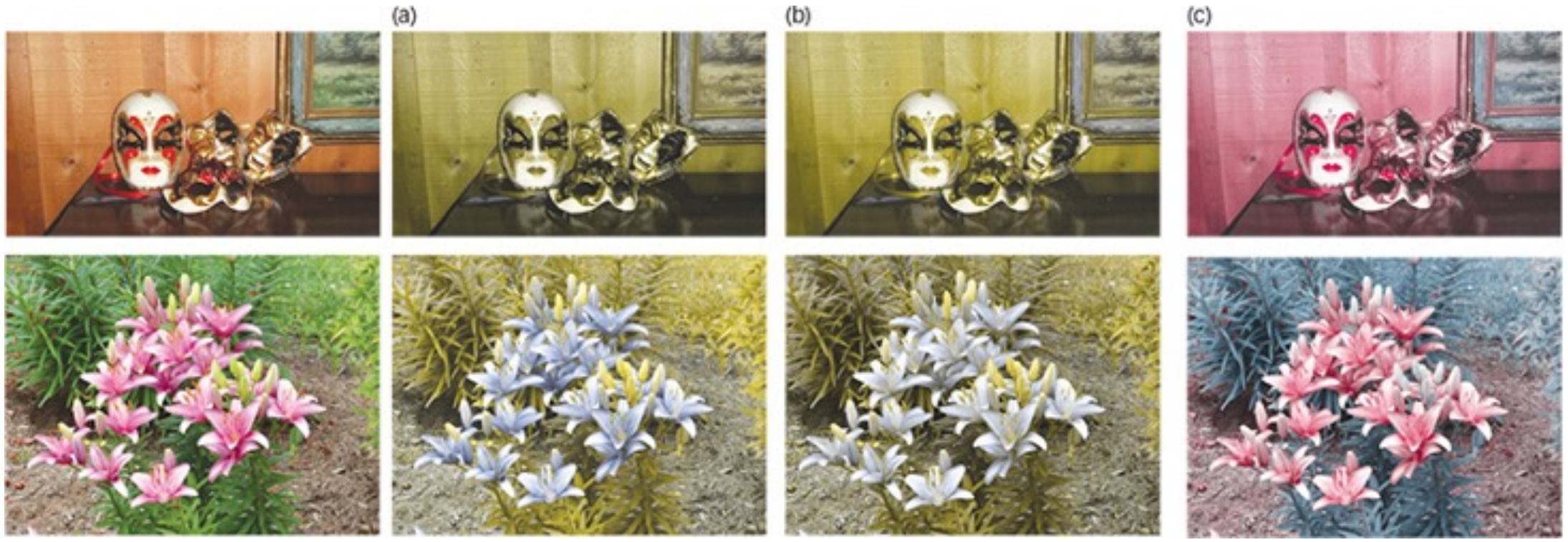
normale

protanopia

deuteranopia

tritanopia

normale protanope. deuteranope. tritanope



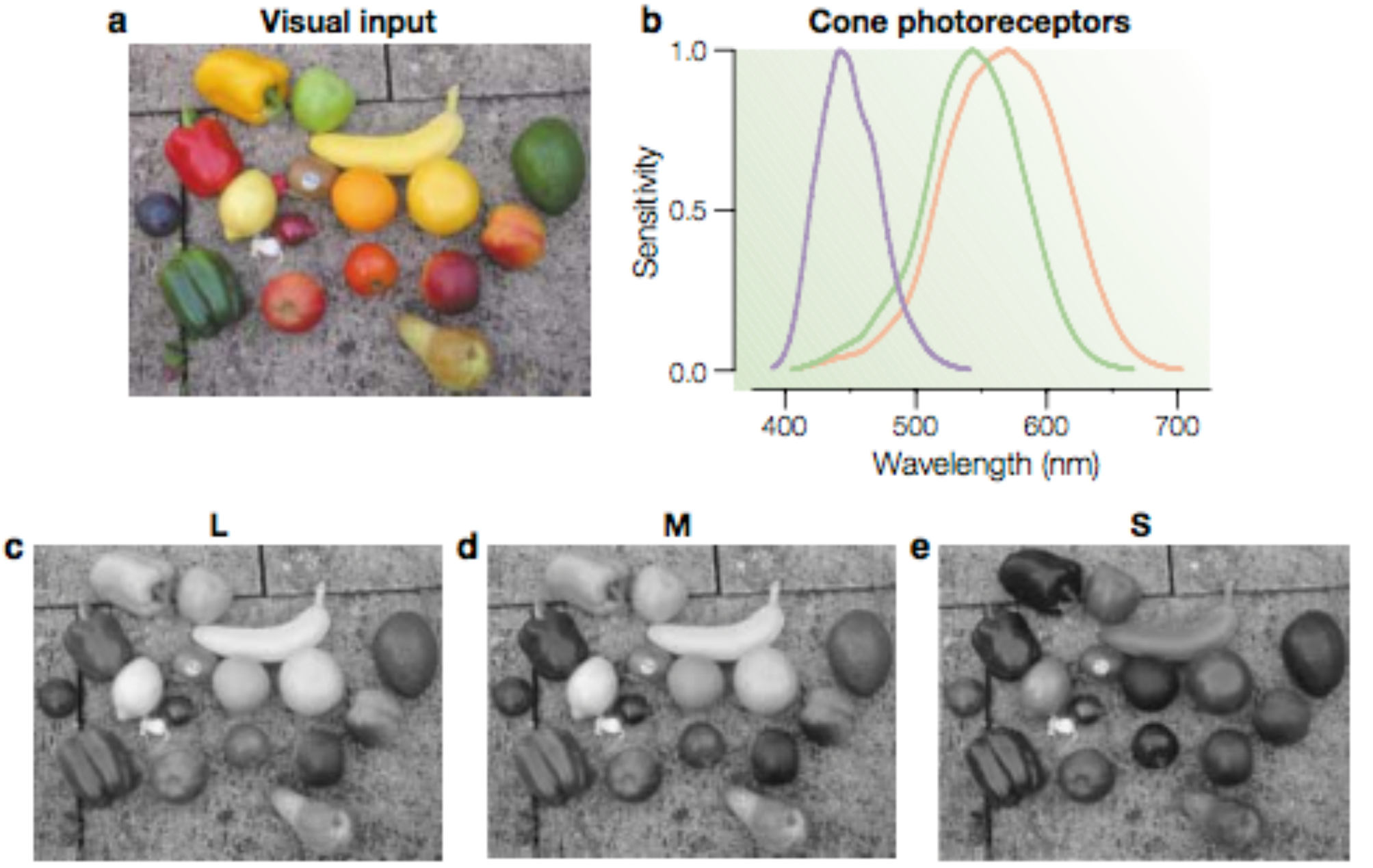
-L **-M** **-S**

Gegenfurtner (2003) *Nat Rev Neurosc 4,* 563-572

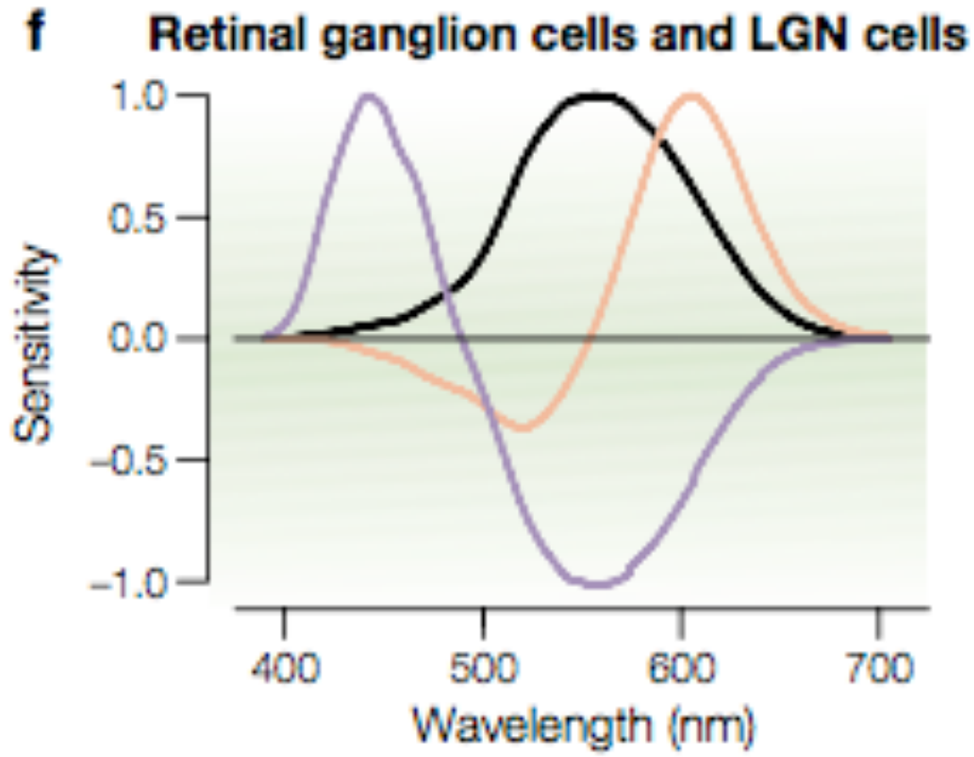
CORTICAL MECHANISMS OF COLOUR VISION

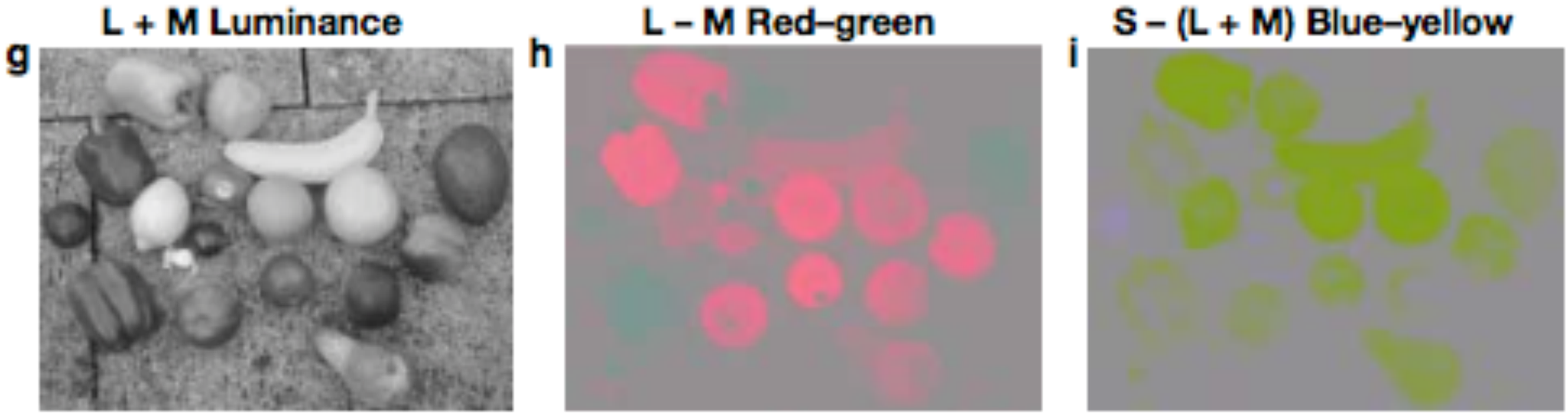
Karl R. Gegenfurtner

The perception of colour is a central component of primate vision. Colour facilitates object perception and recognition, and has an important role in scene segmentation and visual memory. Moreover, it provides an aesthetic component to visual experiences that is fundamental to our perception of the world. Despite the long history of colour vision studies, much has still to be learned about the physiological basis of colour perception. Recent advances in our understanding of the early processing in the retina and thalamus have enabled us to take a fresh look at cortical processing of colour. These studies are beginning to indicate that colour is processed not in isolation, but together with information about luminance and visual form, by the same neural circuits, to achieve a unitary and robust representation of the visual world.



Gegenfurtner (2003) *Nat Rev Neurosc 4,* 563-572





Gegenfurtner (2003) *Nat Rev Neurosc 4,* 563-572

0270-6474/84/0401-0309$02.00/0

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ANATOMY AND PHYSIOLOGY OF A COLOR SYSTEM IN THE PRIMATE VISUAL CORTEX[1]

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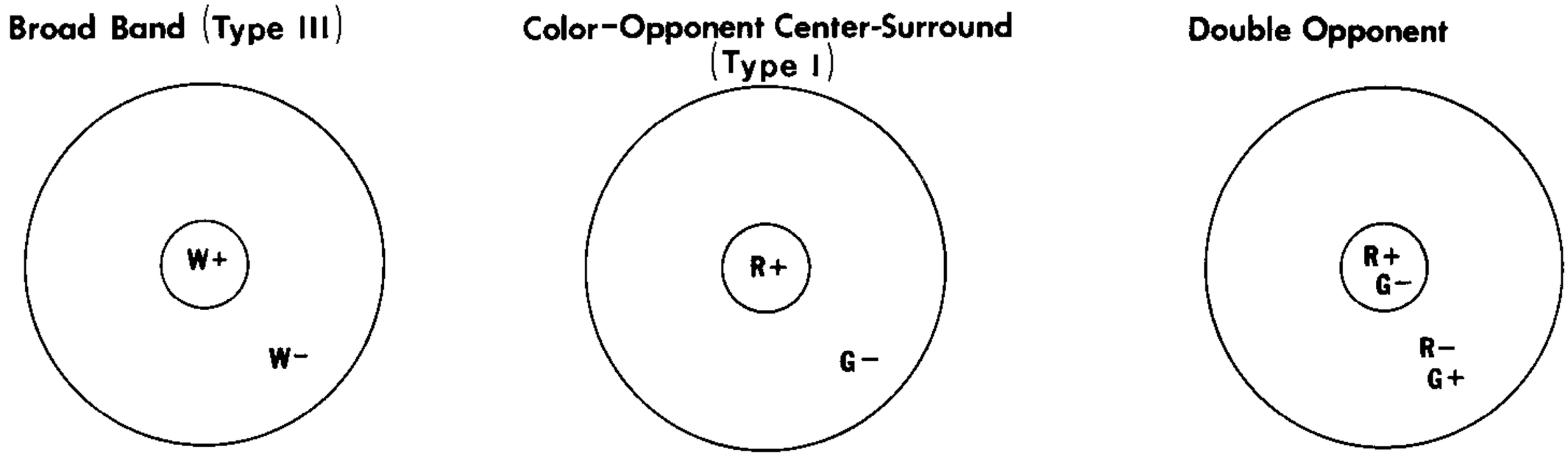
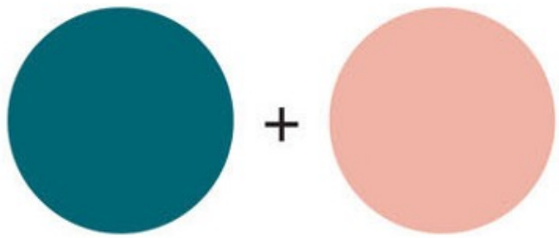
Received August 16, 1983; Revised October 28, 1983; Accepted October 28, 1983



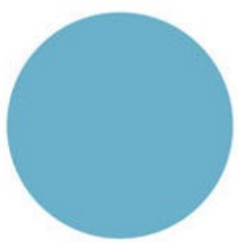
cancellazione della tinta

(*a*) Here is a light that looks bluish green.

(*b*) If I add a bit of light that looks red…

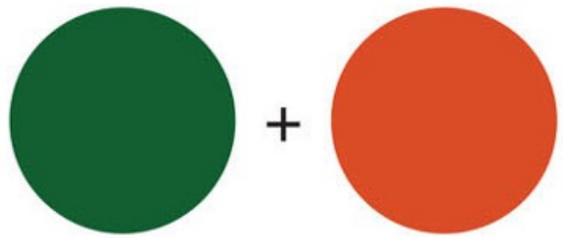


(*c*) …I can cancel the green, and I will be left with only the blue.

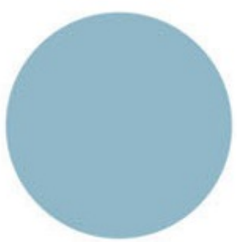


(*d*) If the light looks greener…

(*e*) …more red will be needed to cancel the green…

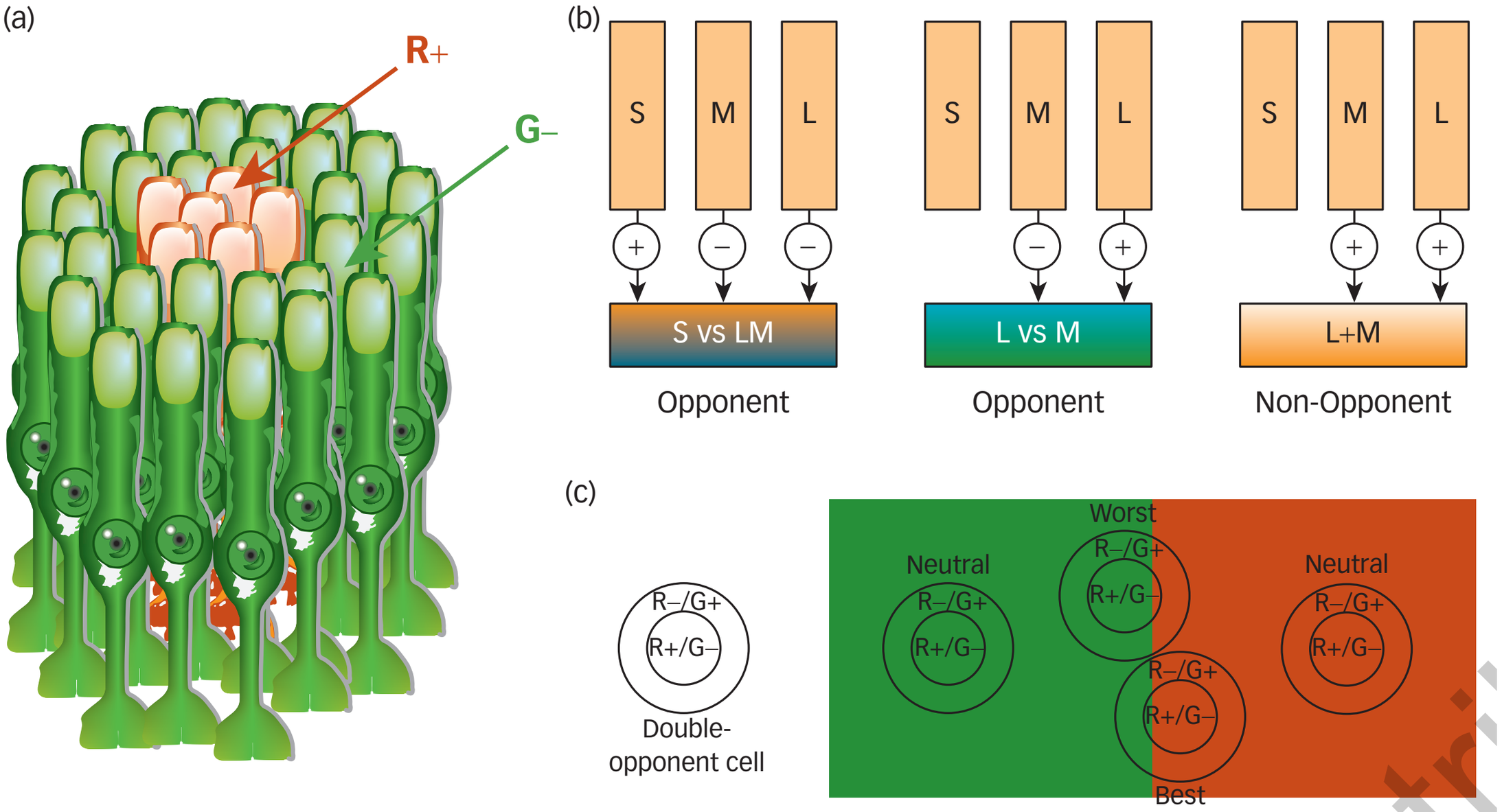


(*f*) …and I will be left with the weaker blue component.



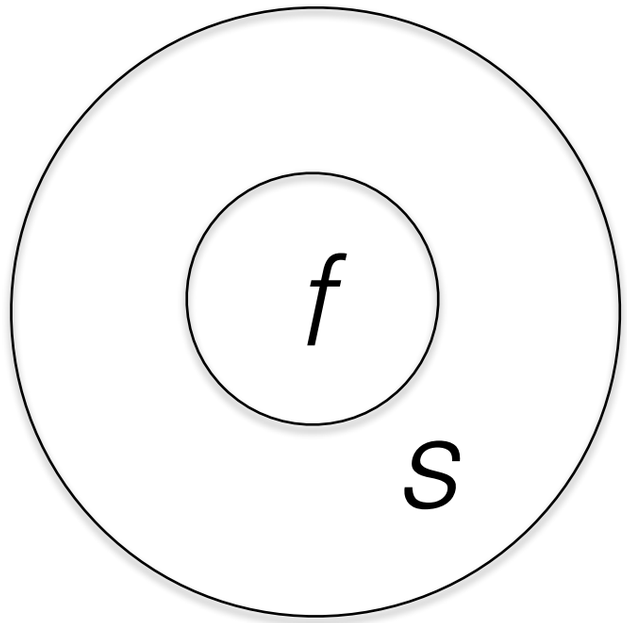
***SENSATION & PERCEPTION 4e*, Figure 5.15**

CR opponenti *doppi*



contrasto cromatico

$$(L\,f - Ls)/(Ls)$$



$$(Cf - Cs)/(Cs)$$

$$(M\,f - Ms)/(Ms)$$

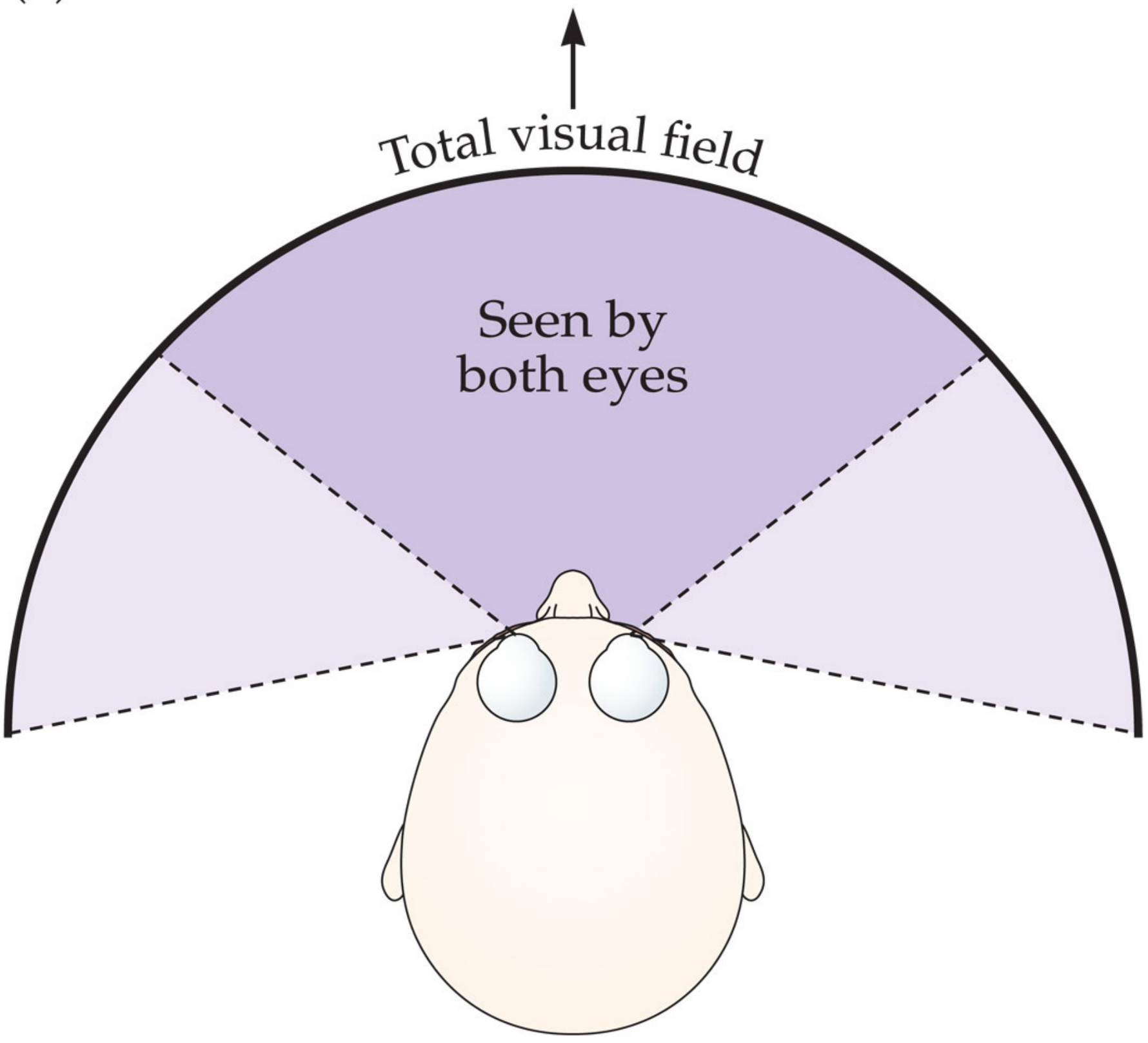
$$(L\,f - Ls)/(Ls)$$

cone excitation ratios

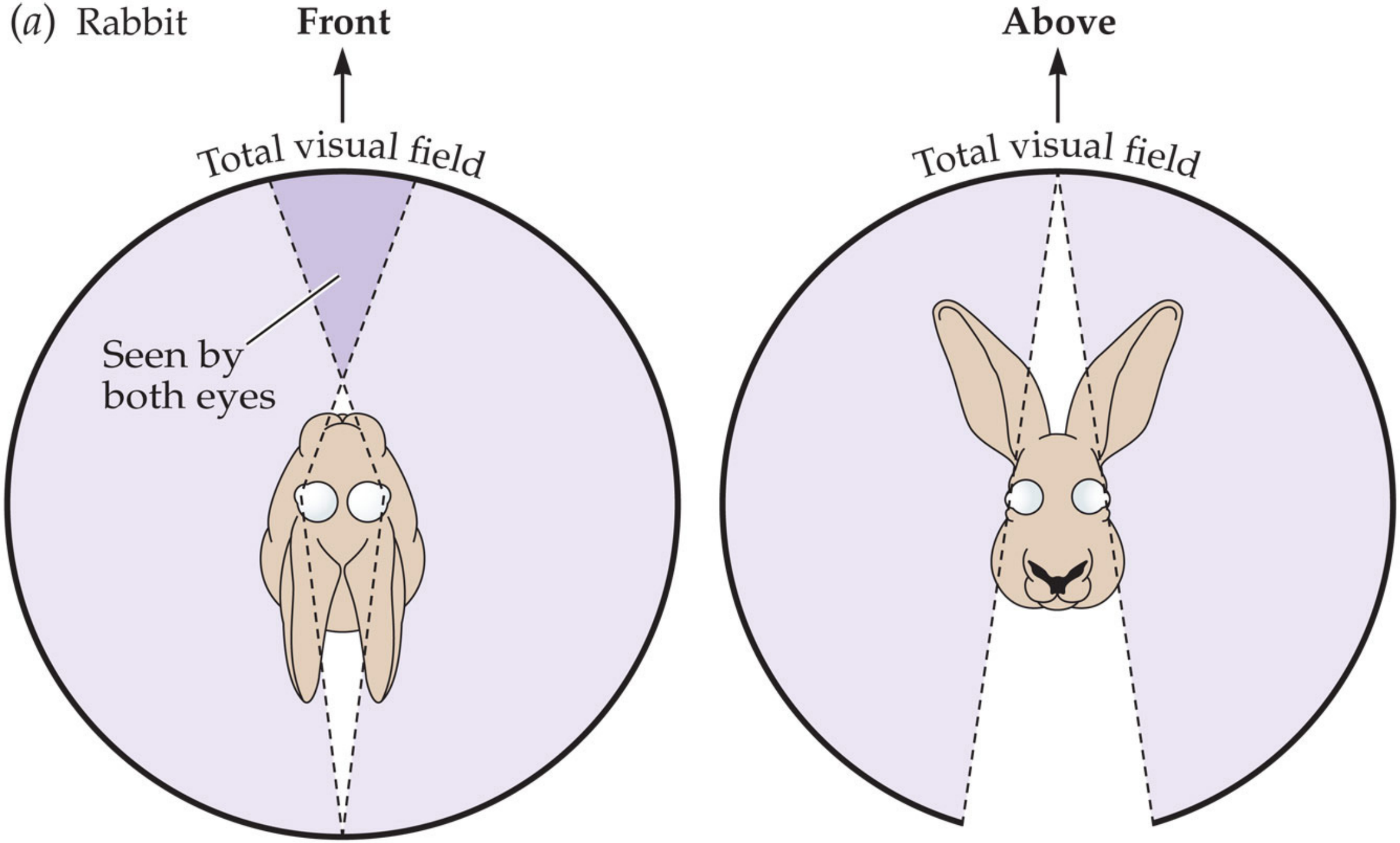
Lezioni 28-29

visione di basso livello: disparità binoculare

(*b*) Human

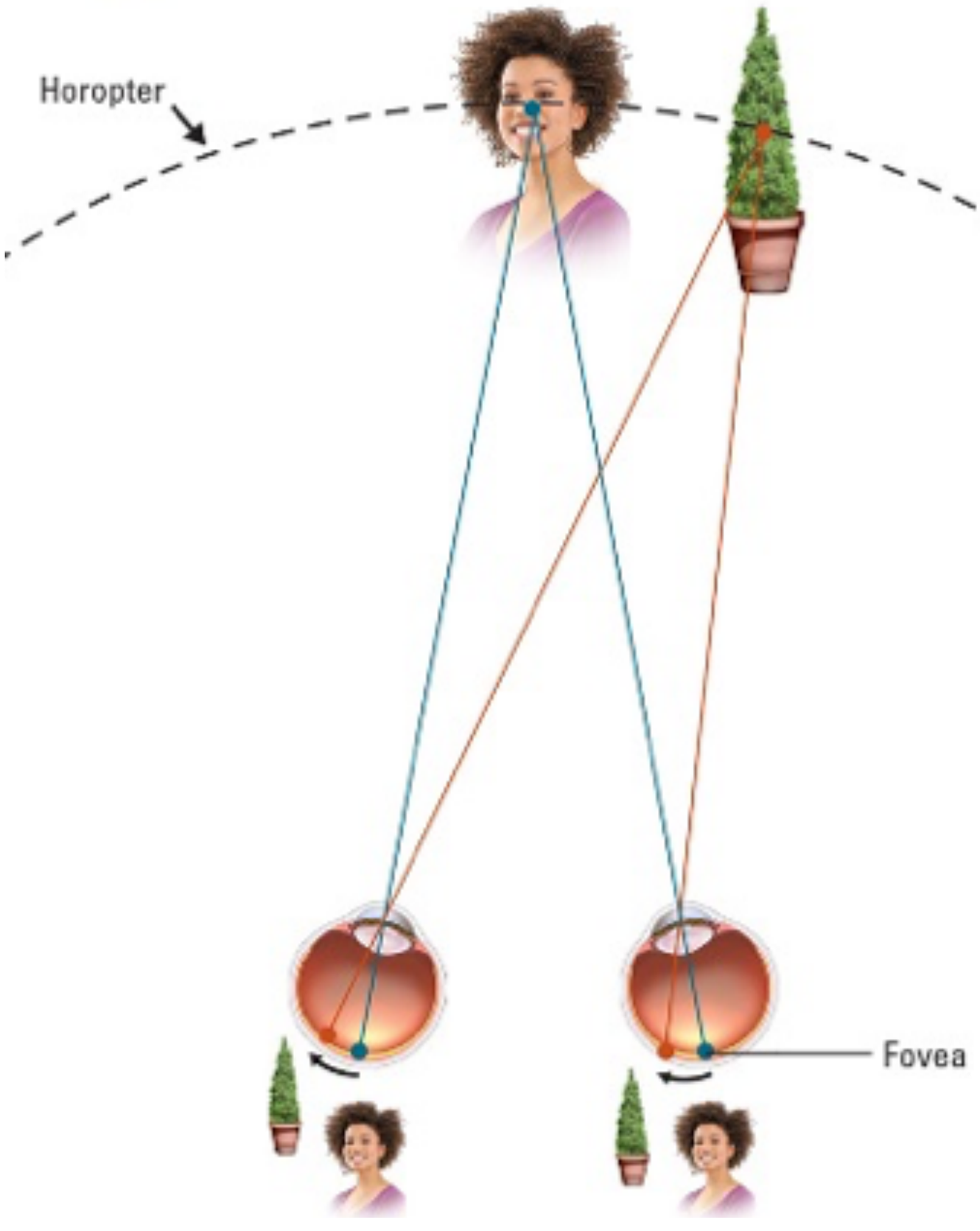


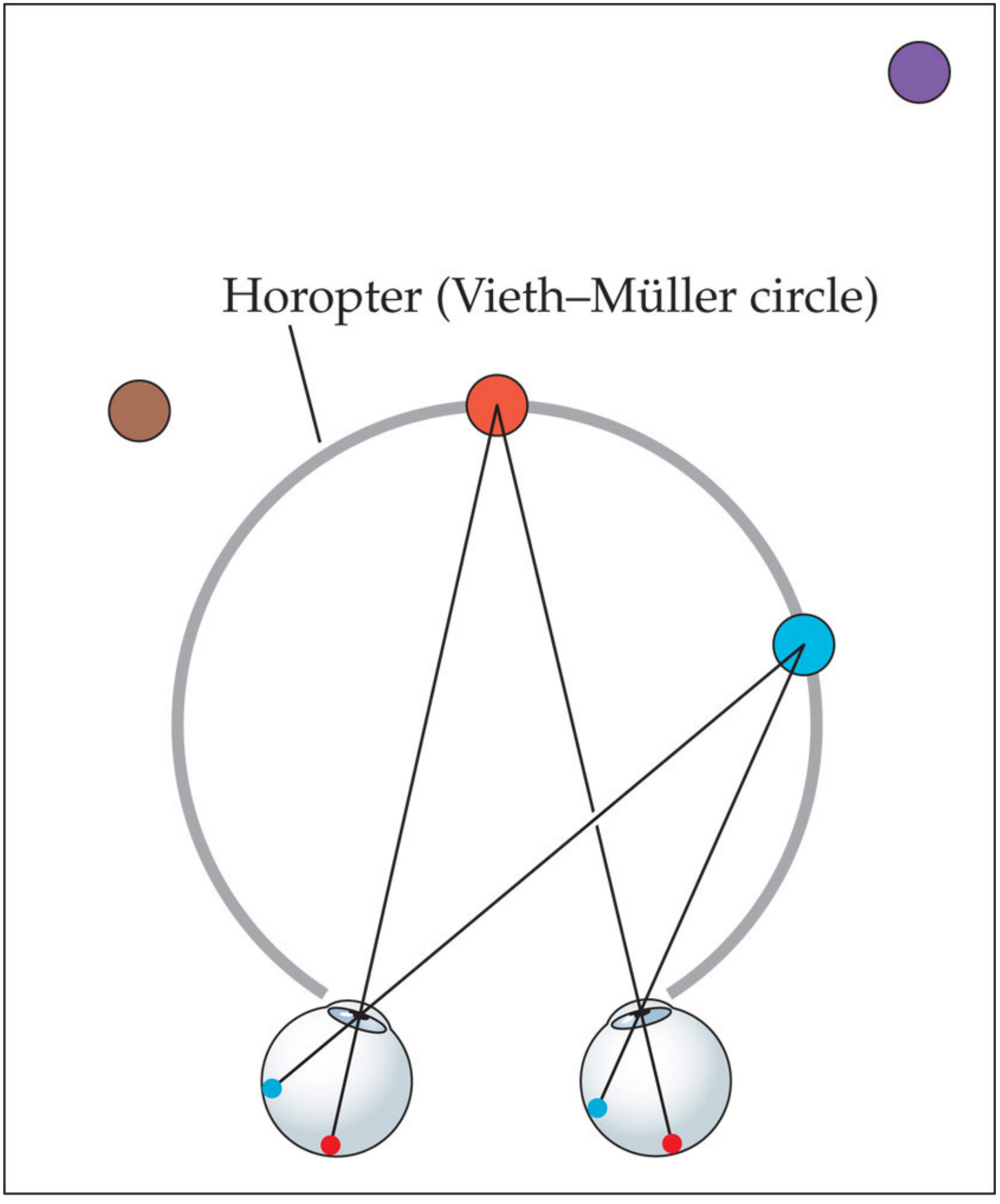
***SENSATION & PERCEPTION 4e,* Figure 6.3 (Part 2)**



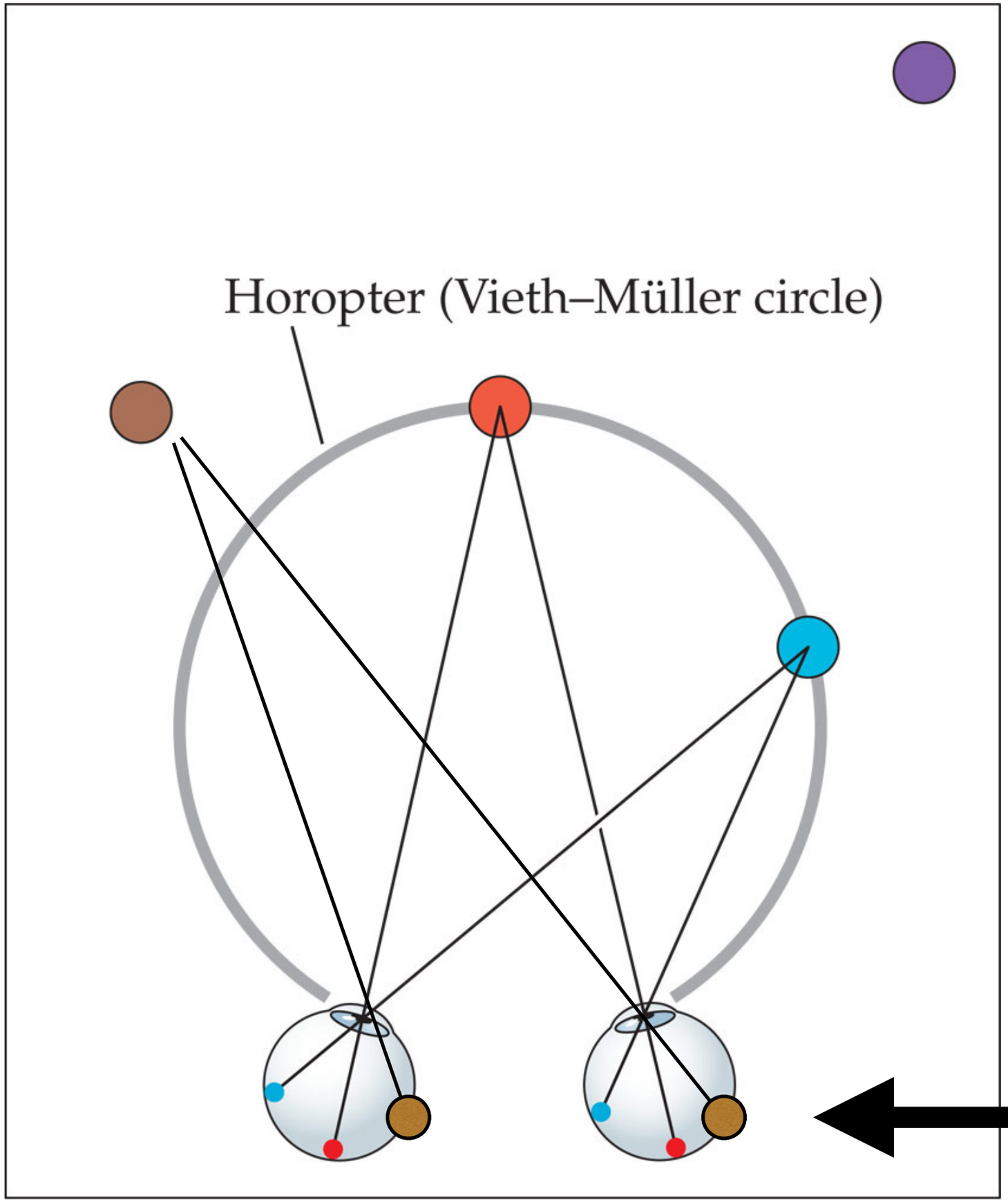
***SENSATION & PERCEPTION 4e,* Figure 6.3 (Part 1)**


Horopter


Horopter
Fovea

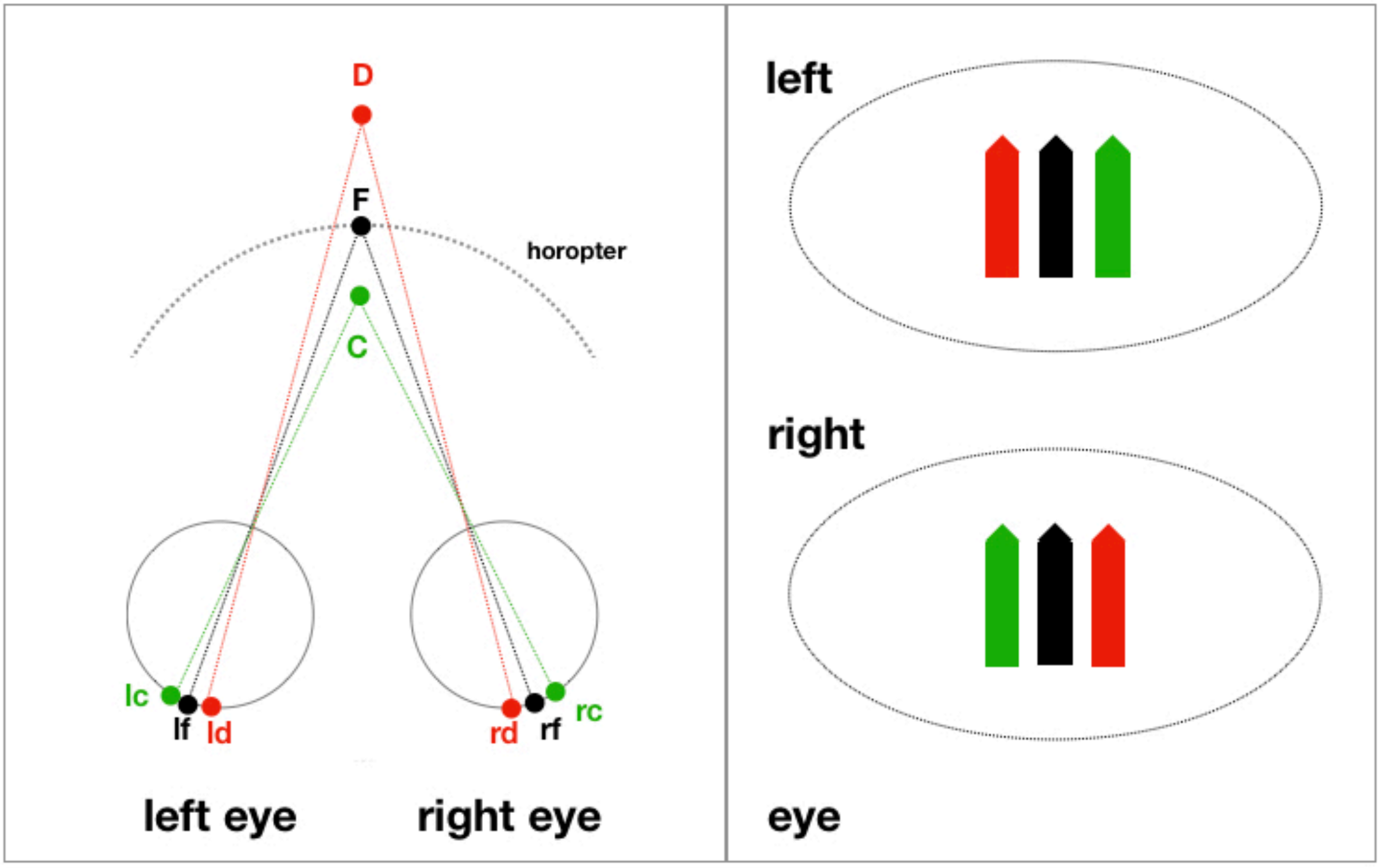


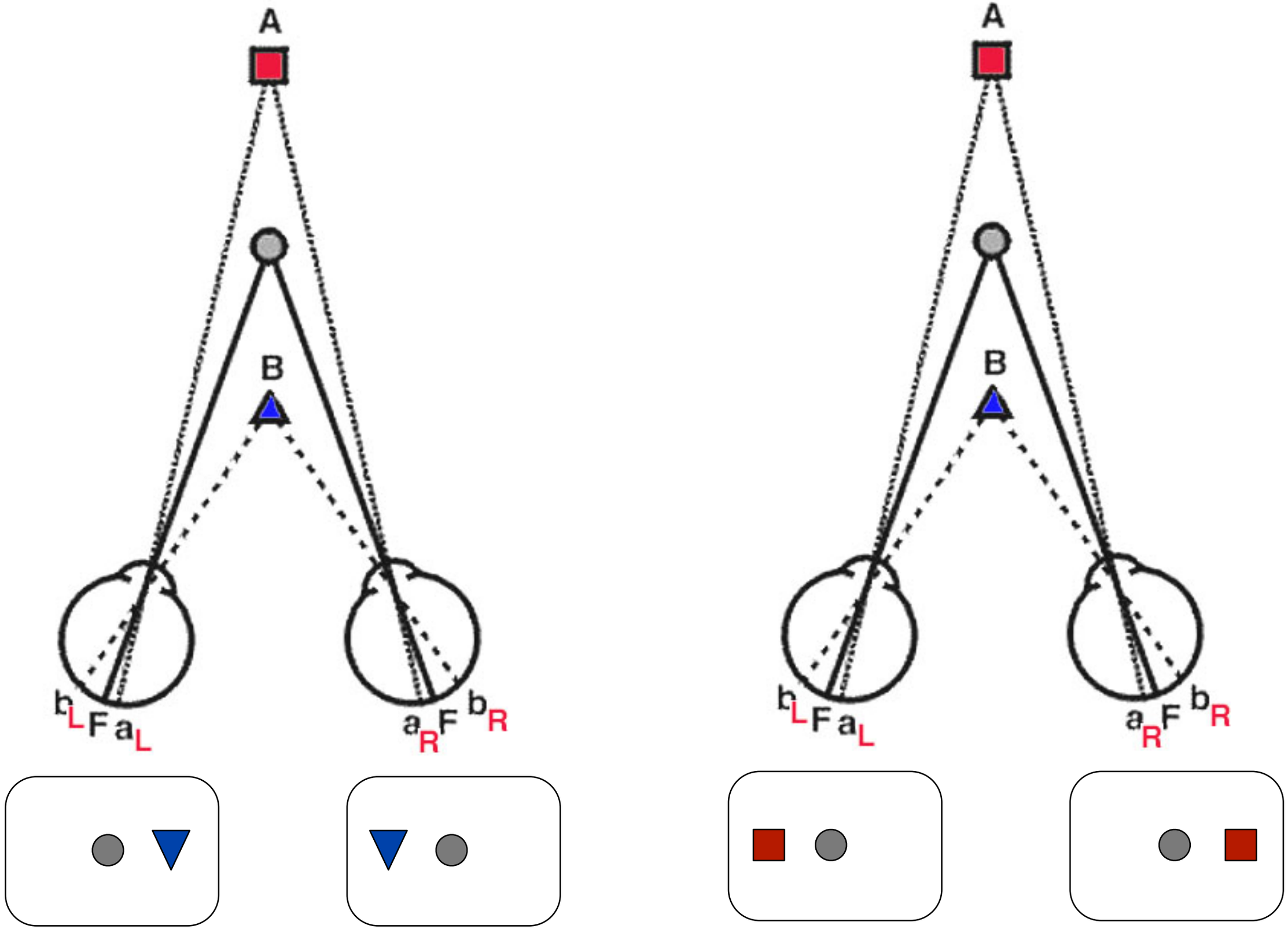
***SENSATION & PERCEPTION 4e*, Figure 6.25**



retinal disparity

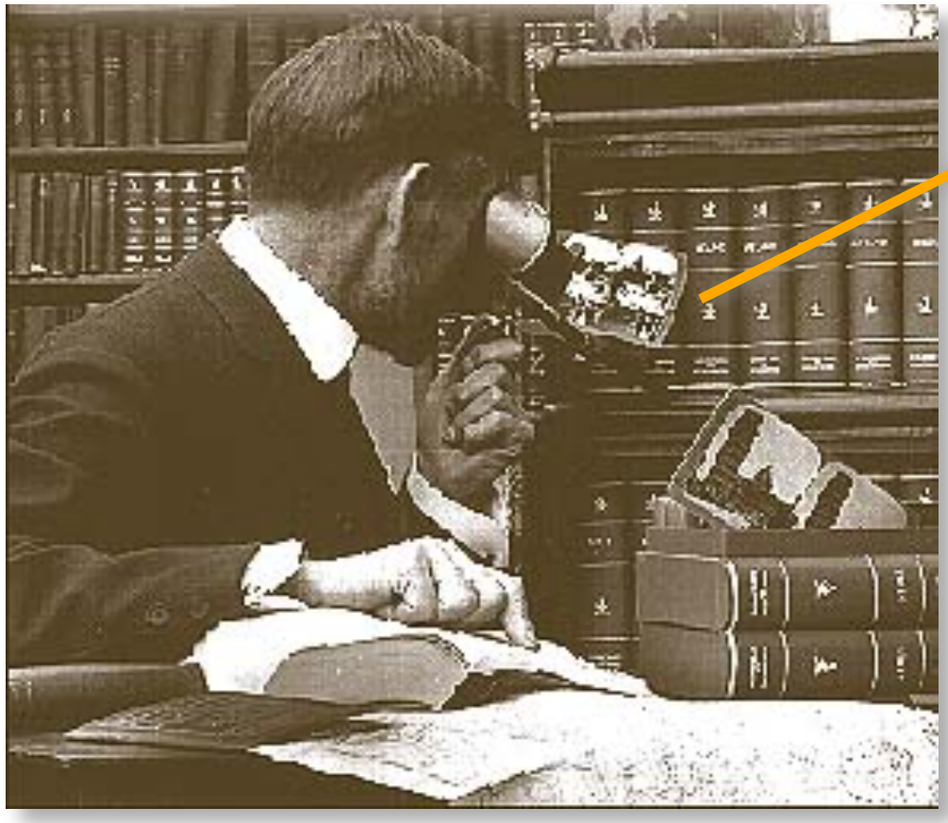
***SENSATION & PERCEPTION 4e*, Figure 6.25**

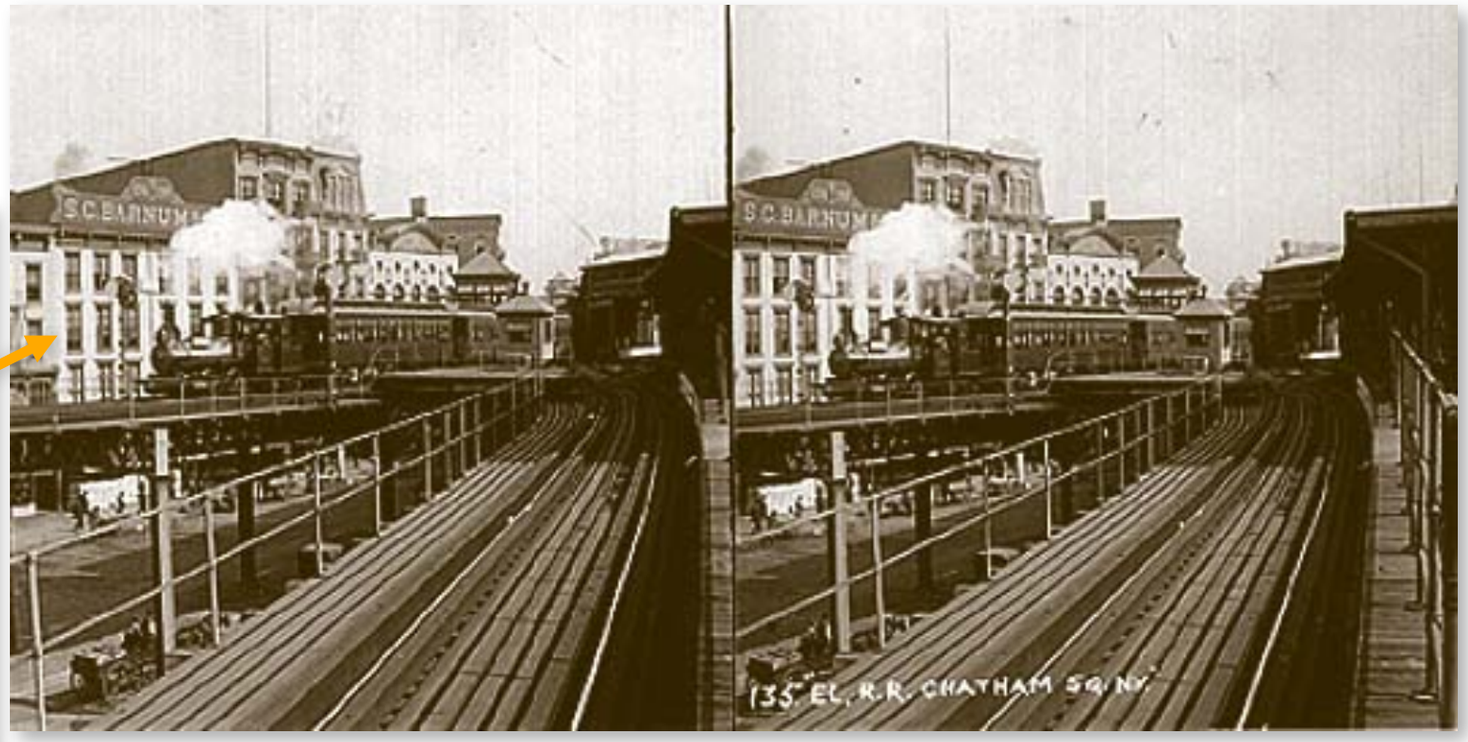

D
F
horopter
C
lc
lf
ld
rd
rf
rc
left eye
right eye
left
right
eye



disparità crociata **disparità non-crociata**

Charles Weathstone



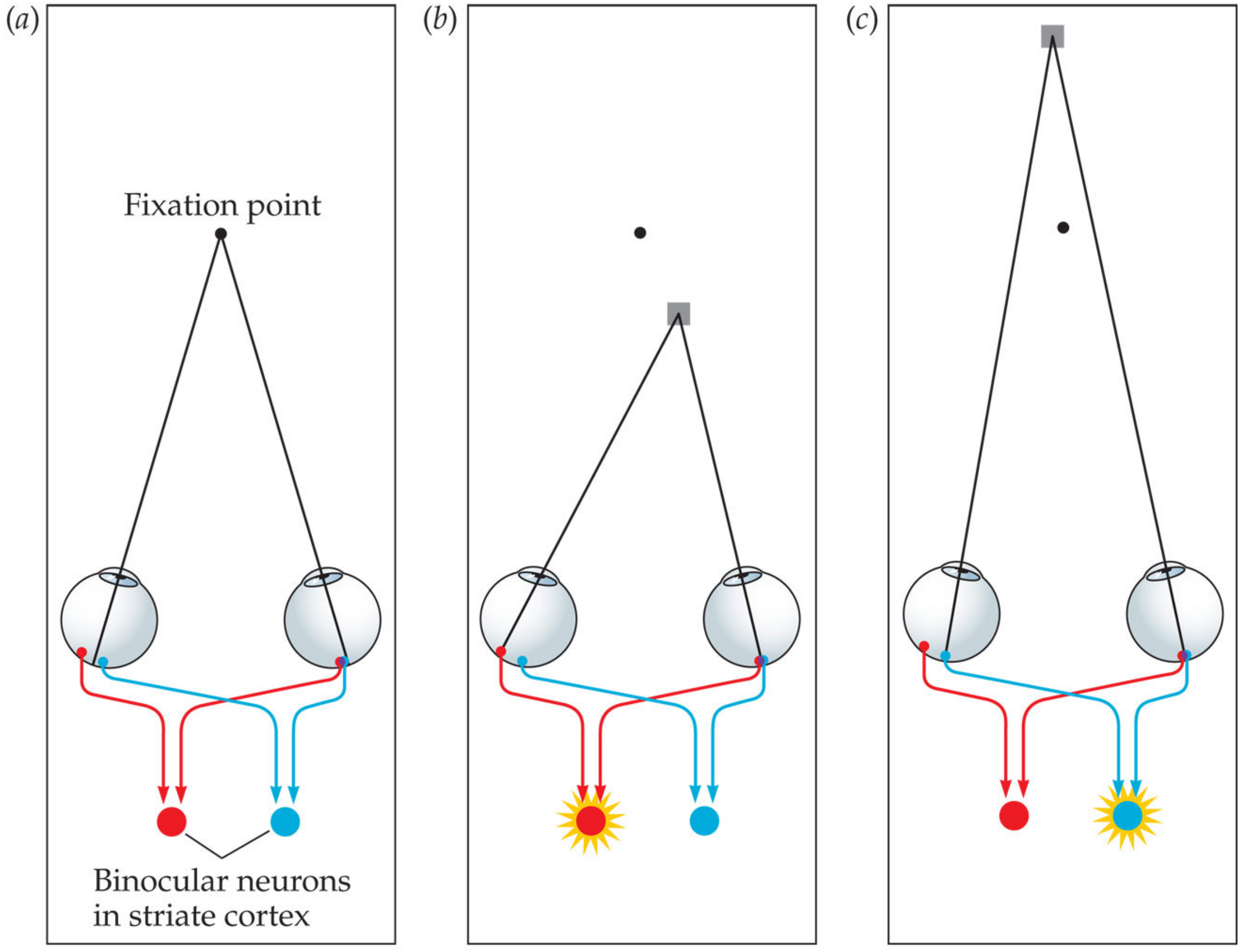


stereoscopio

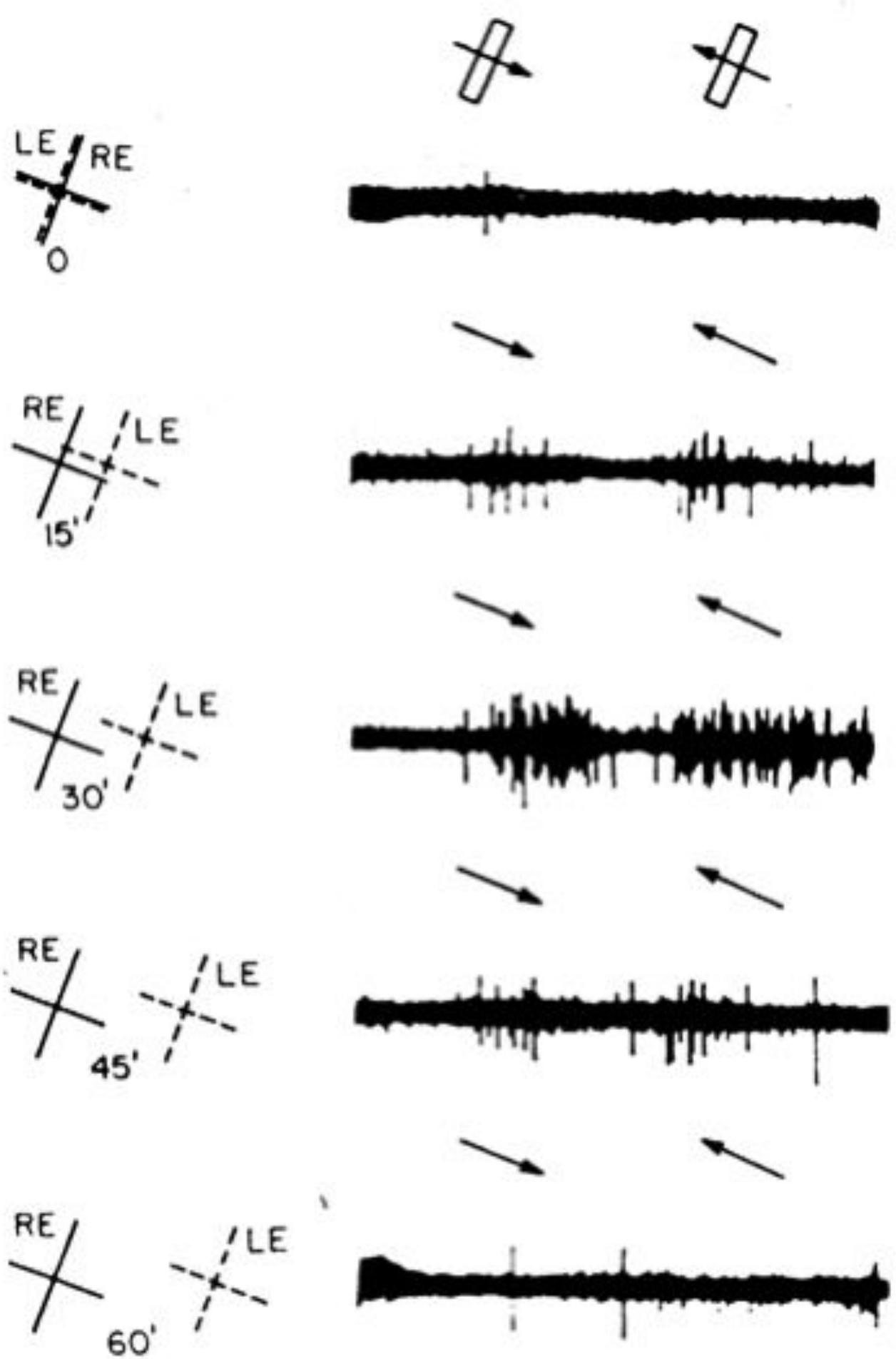
disparità

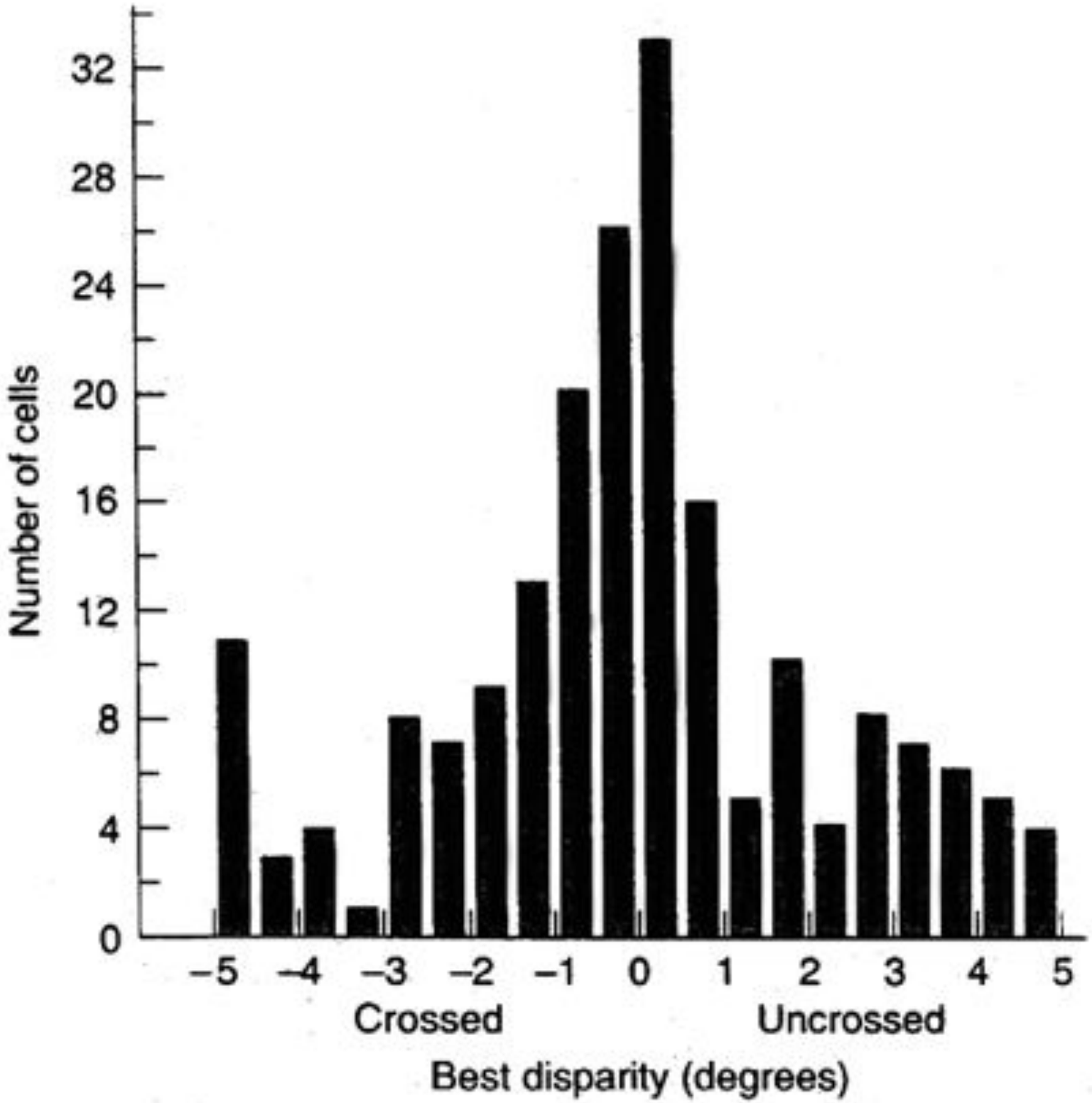
stereogramma

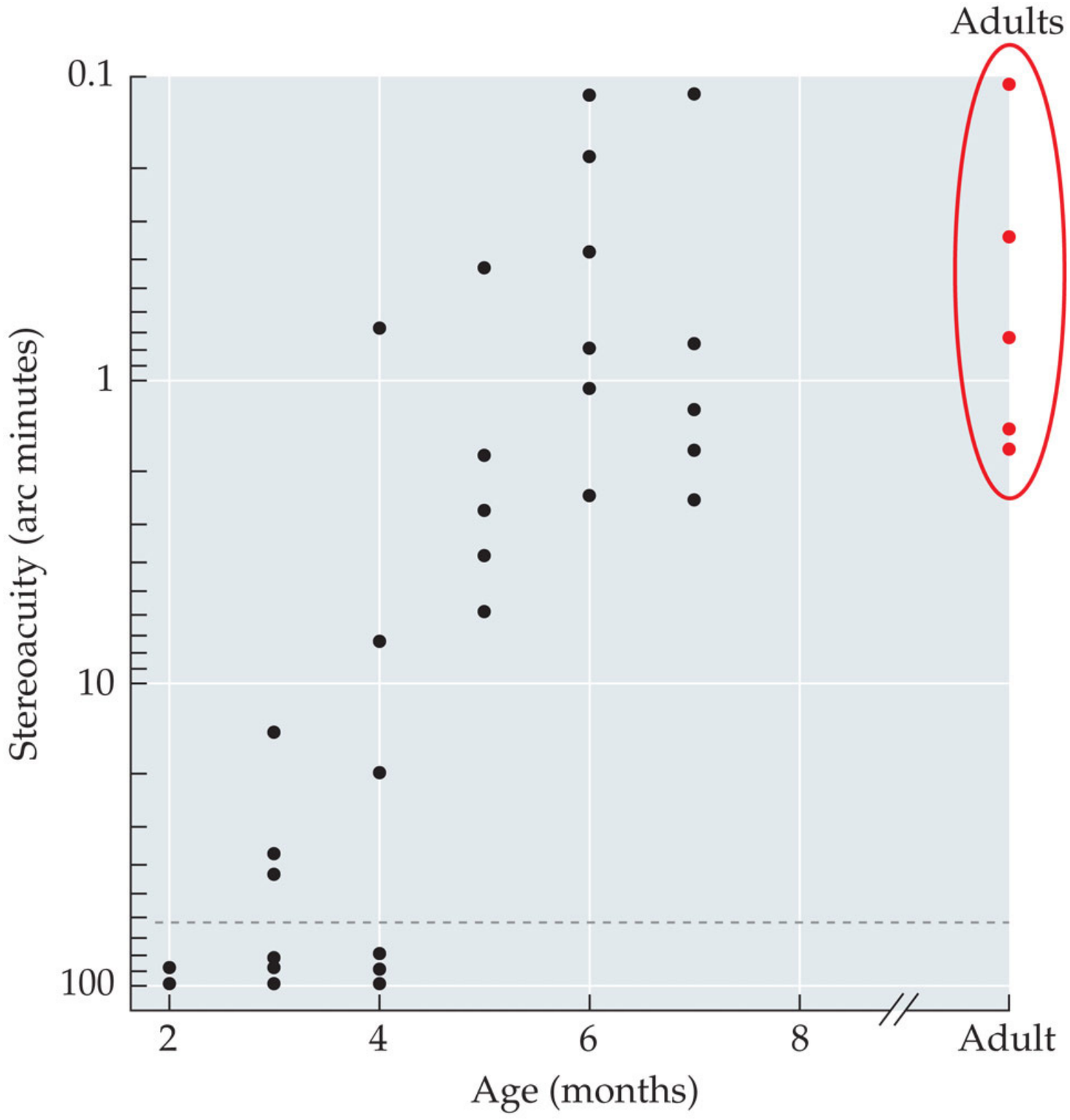
anaglifo



***SENSATION & PERCEPTION 4e*, Figure 6.40**


LE
RE
0
RE
LE
15'
RE
LE
30'
RE
LE
45'
RE
LE
60'


Number of cells
32
28
24
20
16
12
8
4
0
−5
−4
−3
−2
−1
0
1
2
3
4
5
Crossed
Uncrossed
Best disparity (degrees)



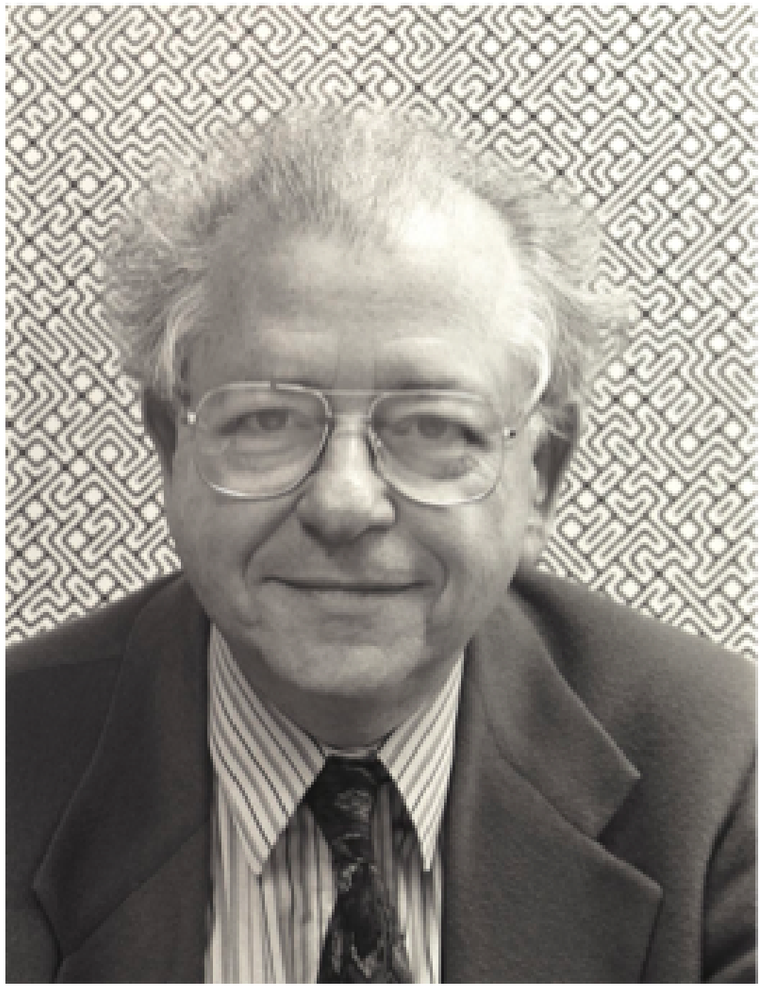
***SENSATION & PERCEPTION 4e*, Figure 6.51**

Binocular Vision and Stereopsis

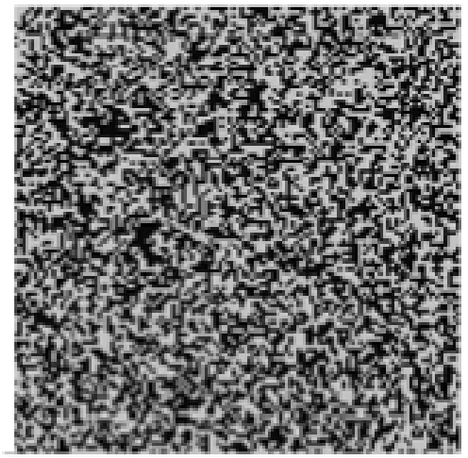
Recovering Stereo Vision

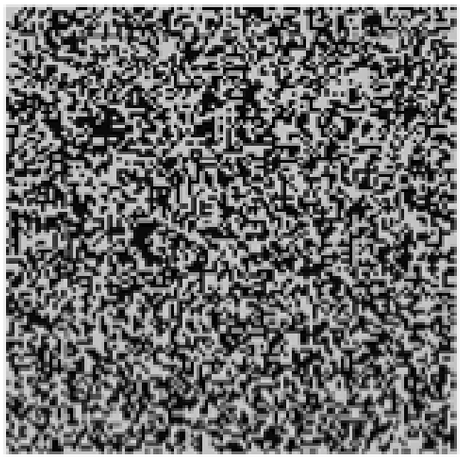
- Susan Berry had strabismus as an infant and never developed stereo vision.
- At age 48, began visual therapy to improve coordination between her two eyes.
- One day she suddenly developed stereo vision!
- Suggests that binocular vision might possibly be developed outside of the normally accepted "critical period."

“with random dot stereograms it is possible … to bypass the peripheral visual apparatus and to project information to the cycoplean eye and to the “mind’s retina” — that is, at a place where the left and right visual pathways combine in the visual cortex” (Julesz, 1971)



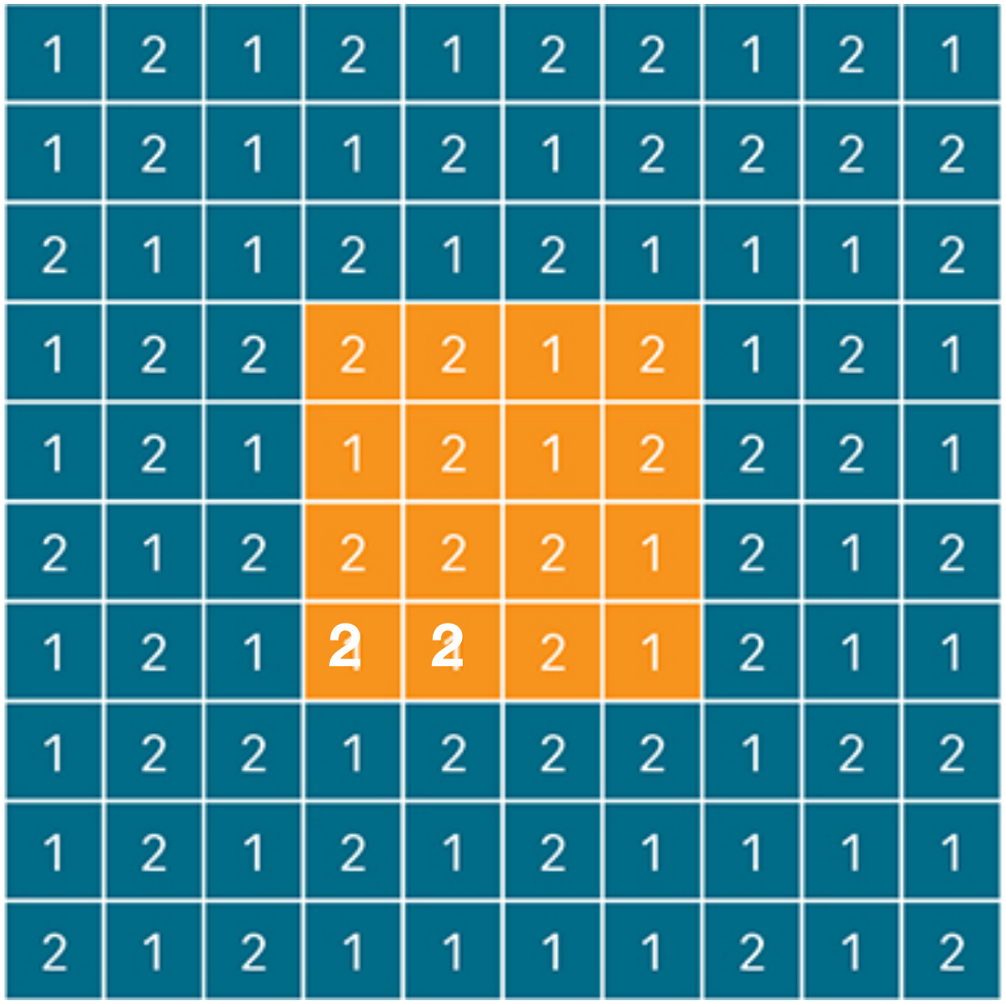
Béla Julesz (1928-2003)





- l’oggetto non esiste nelle viste monoculari
- emerge solo grazie alla fusione di elementi disparati

How Random-Dot Stereograms Are Made



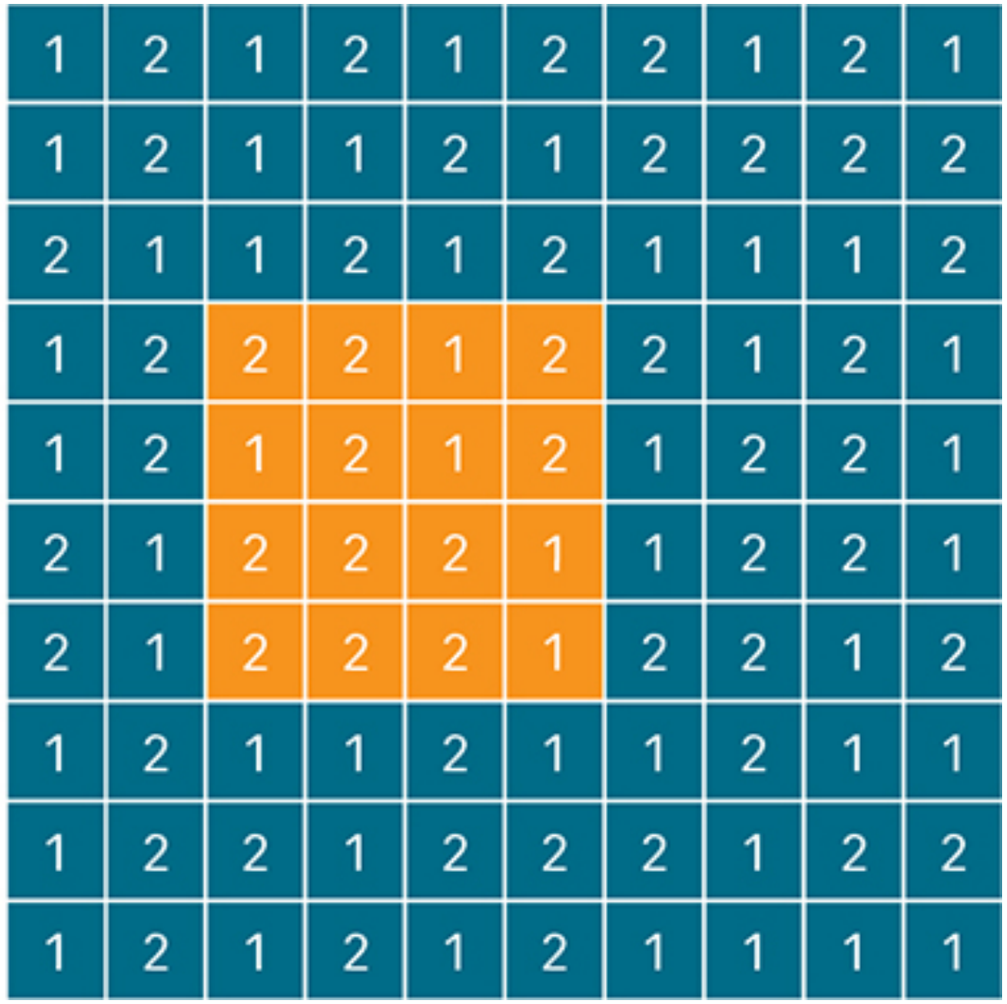


FIGURE 7.30 How Random-Dot Stereograms Are Made

To make a random-dot stereogram, you make a random grid of black and white dots. Each number in the figure represents either a black (1) or white (2) dot. You then copy the image to make two such images. But in the second image, you shift a central section of the first image to the right or left. Thus, the same pattern is represented in each image, but part of it is shifted. When we look at this through a stereograph, the shifted part will appear either in front of or behind of the rest of the dots, depending on which direction it was shifted.