



Erasmus+



Innovative Lifelong e-Learning for Professional Engineers (e-ProfEng)

586391-EPP-1-2017-1-SE-EPPKA2-CBHE-JP

Training in Electrical Engineering Discipline
Modelling and Simulation in Electrical Engineering

Data visualization in data analysis

Perception

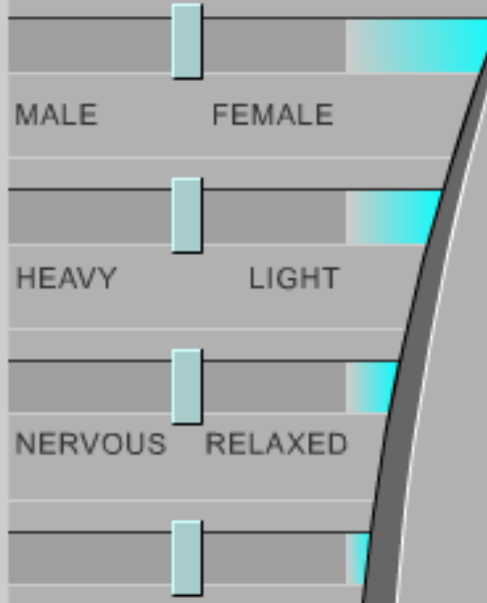
Josip Job

Perception

MALE FEMALE

HEAVY LIGHT

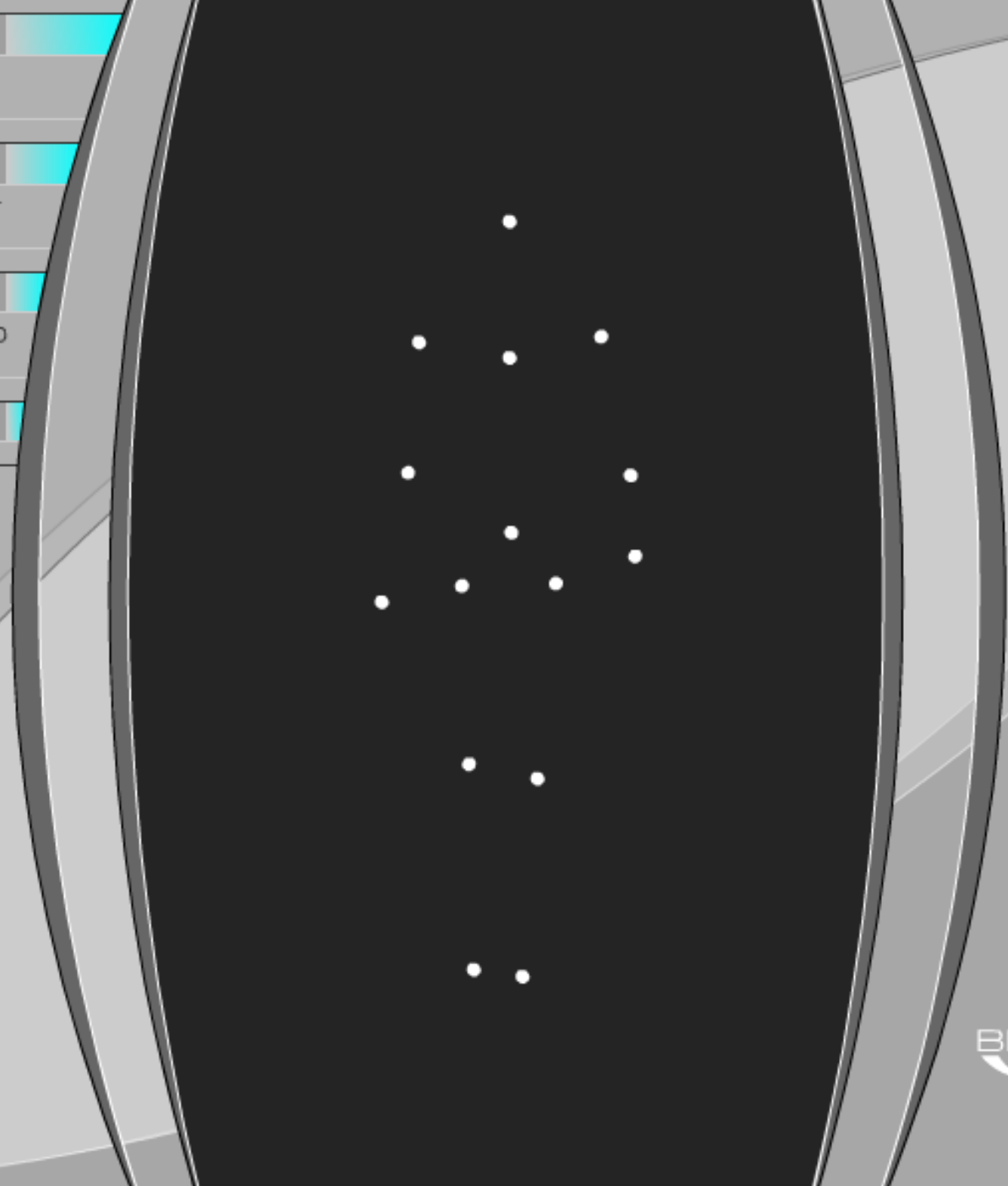
NERVOUS RELAXED



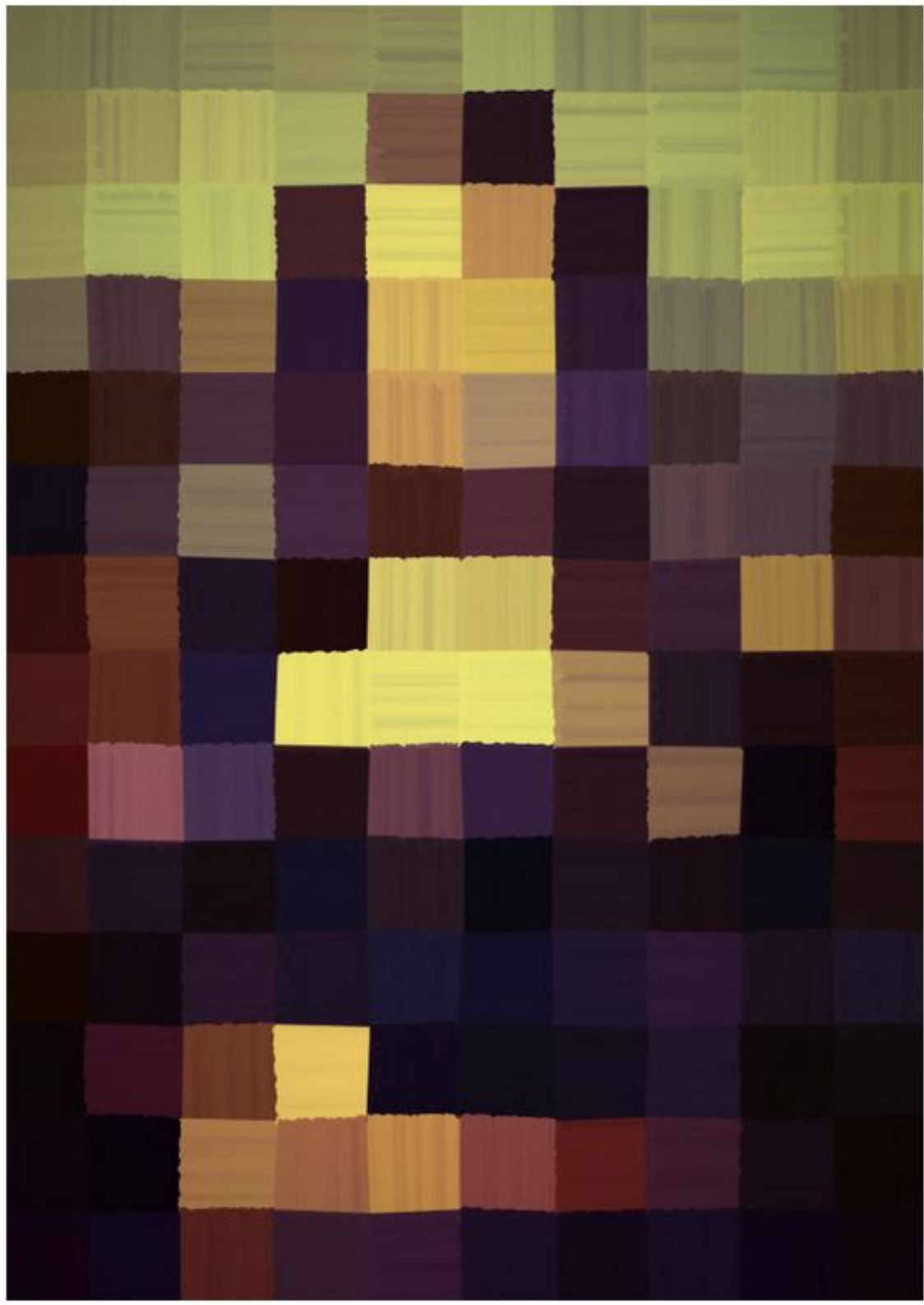
HAPPY SAD

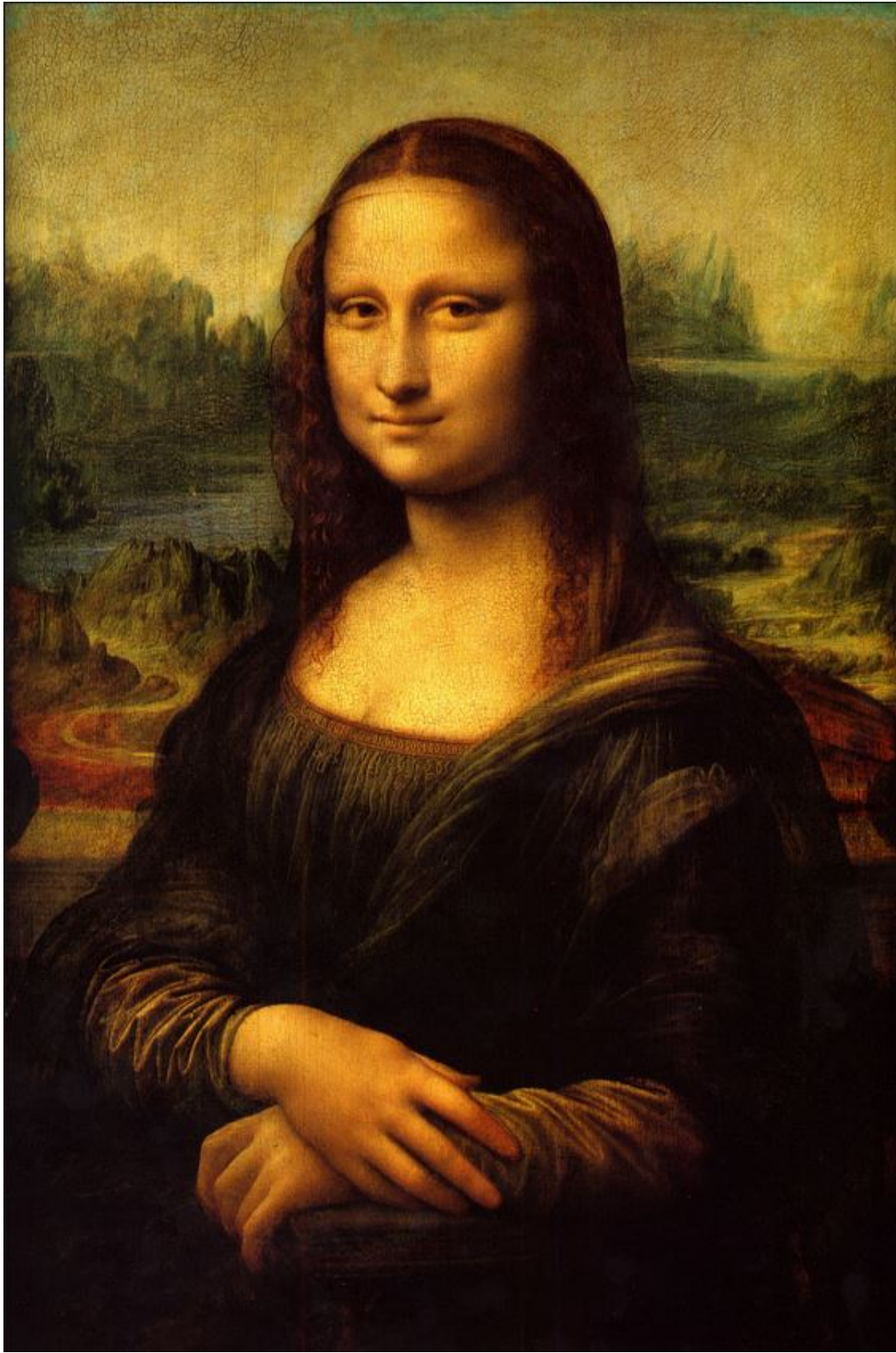


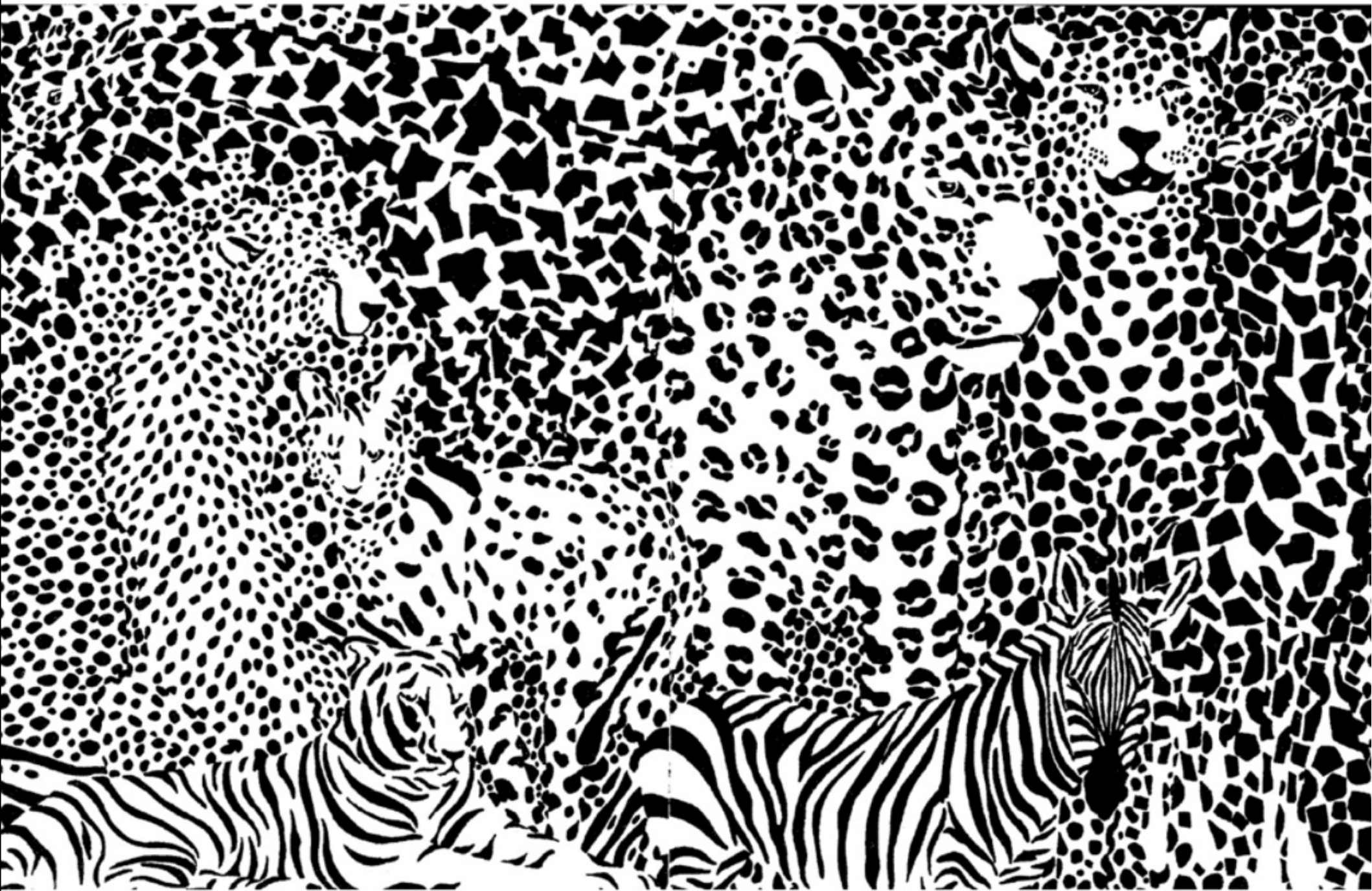
- On/Off
- Lines
- Reset
- Info



more ...

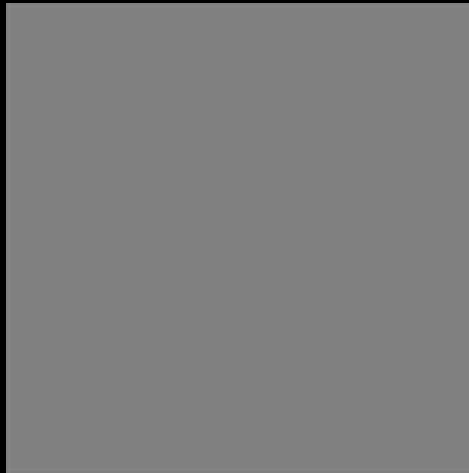






"Ranger Rick", ca. 1980s
Courtesy of Terry Yoo / Ross Whitacker

Which side is brighter?



Which side is brighter?



Which side is brighter?



Which side is brighter?



- Ordinal (O):



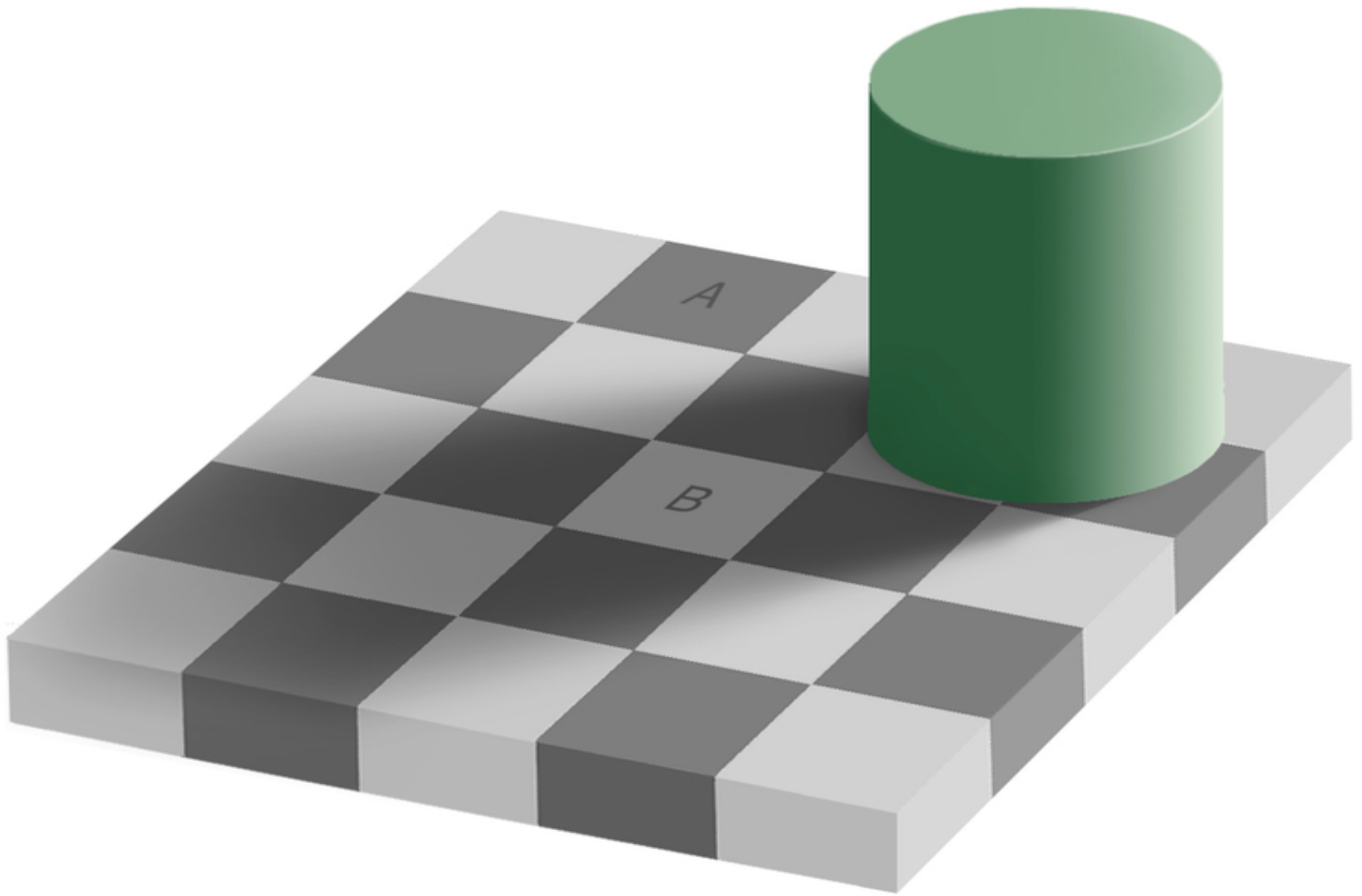
- Quantitative (Q):

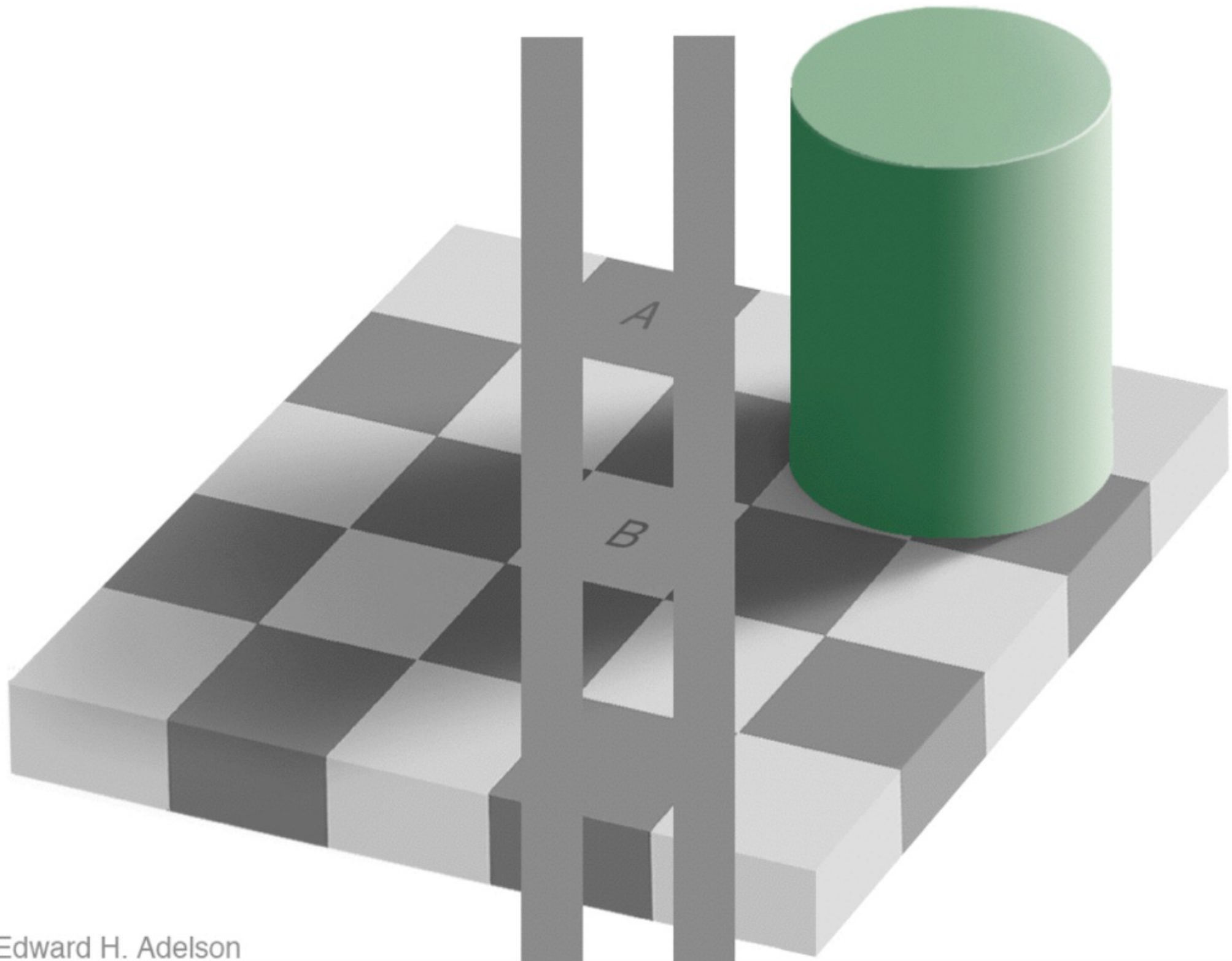


- Color is not ordered

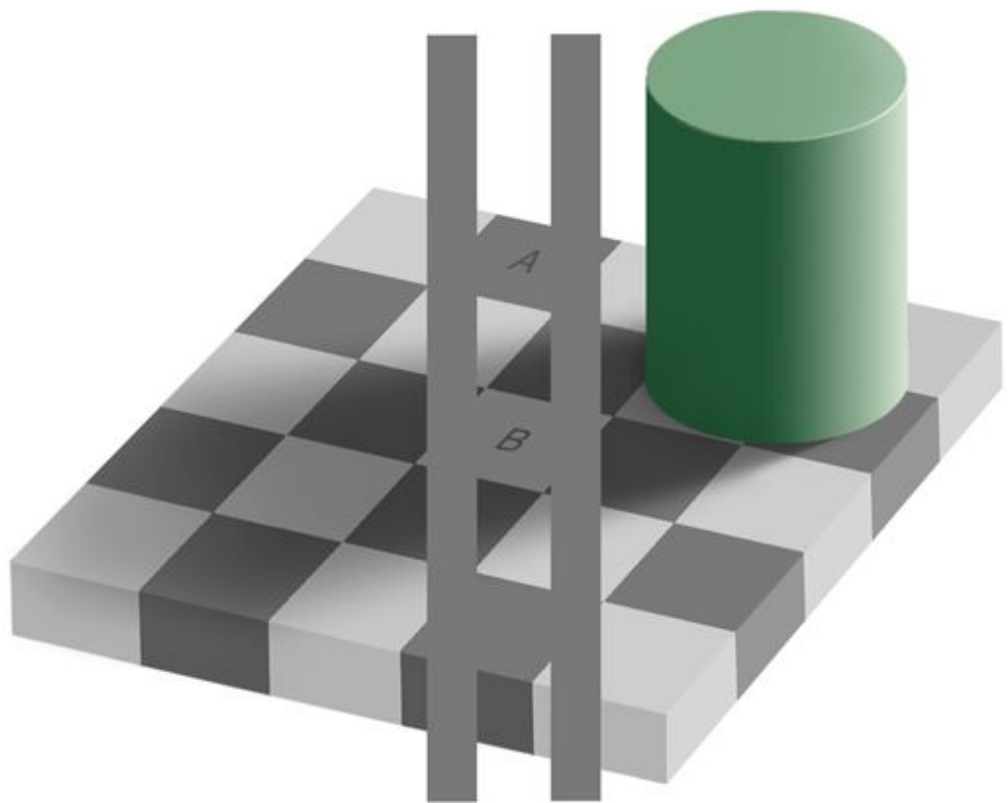
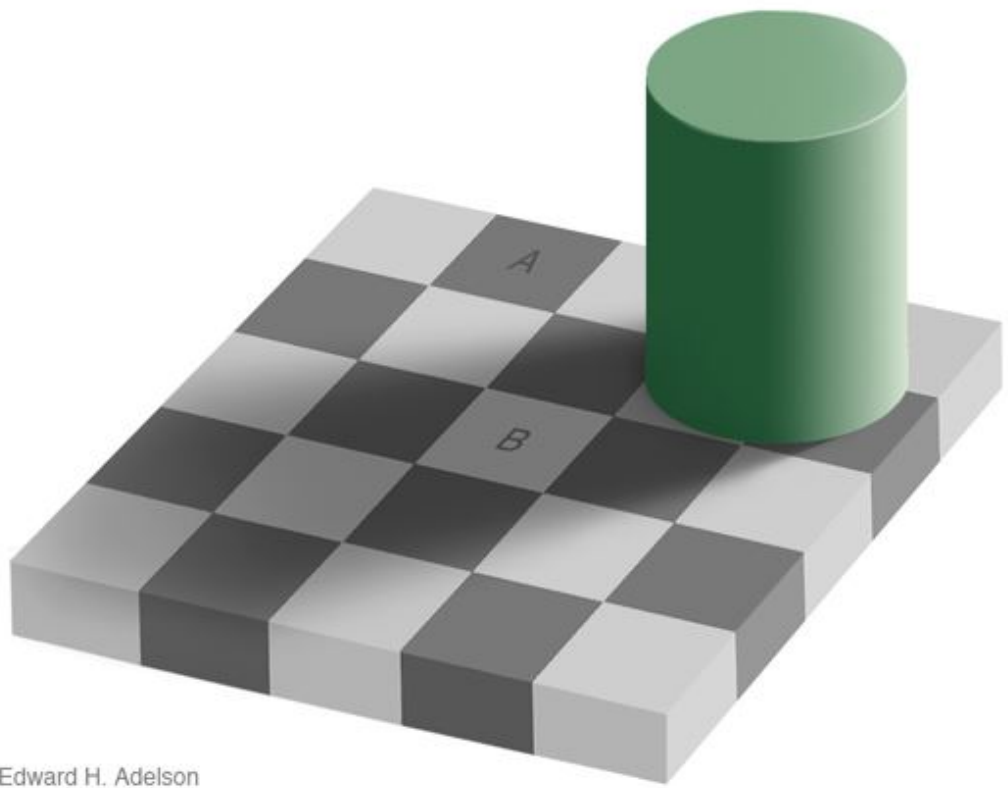
- Nominal (N):



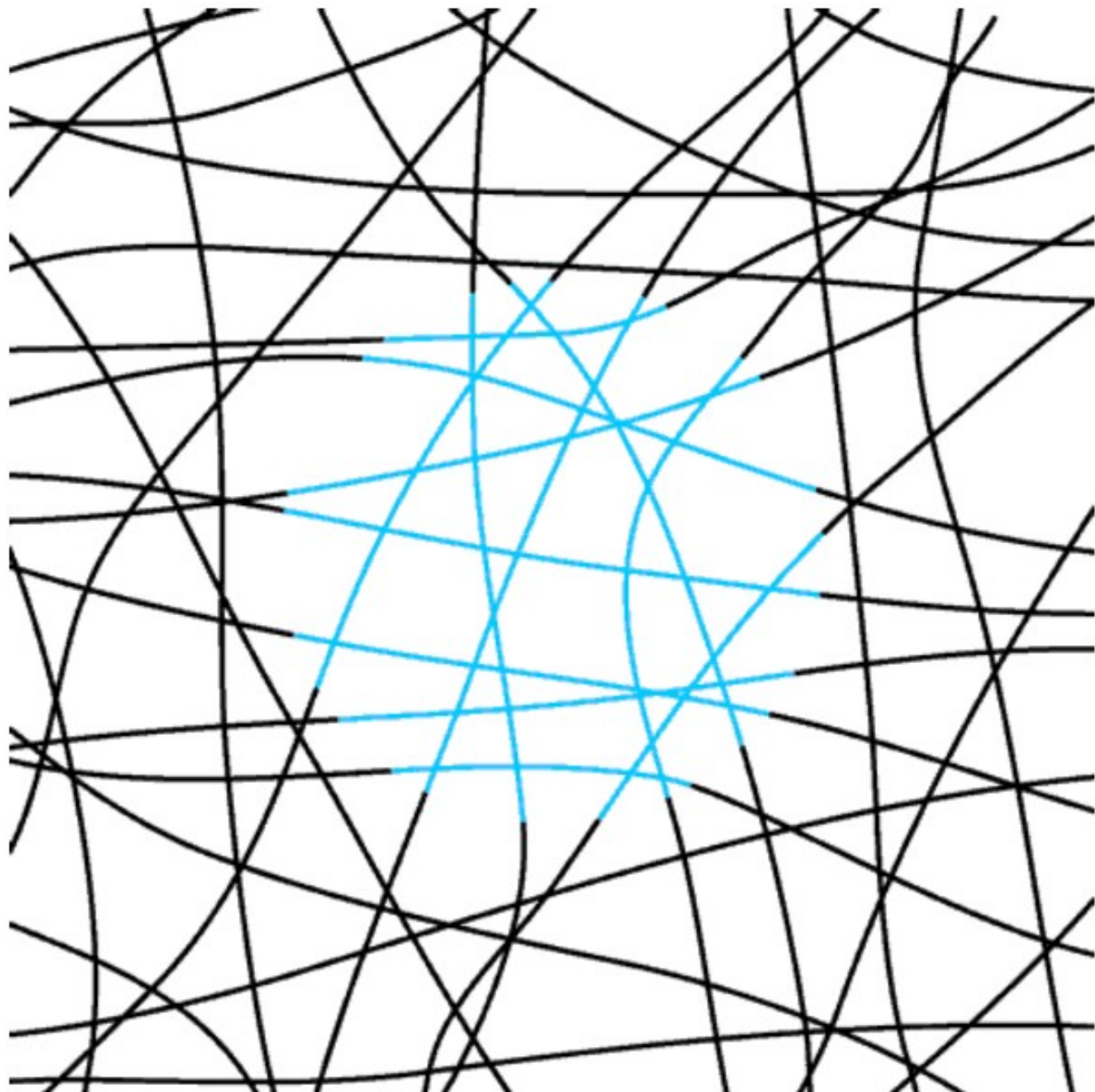




Edward H. Adelson



Edward H. Adelson





4500 RDS E-O-N



CD

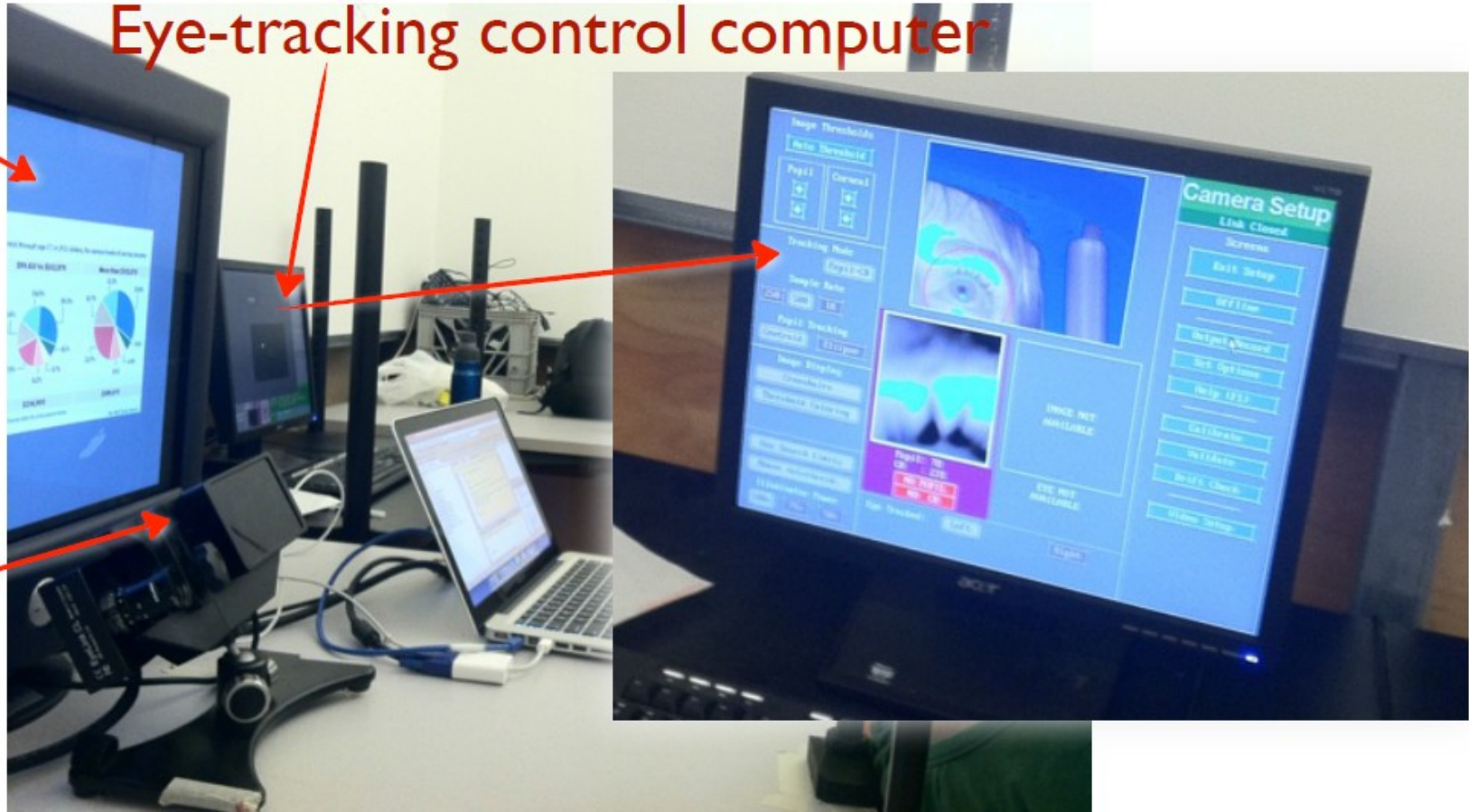
iFun.ru

Eye-Tracking Experiment

Visualization display

Eye-tracking control computer

Infrared camera



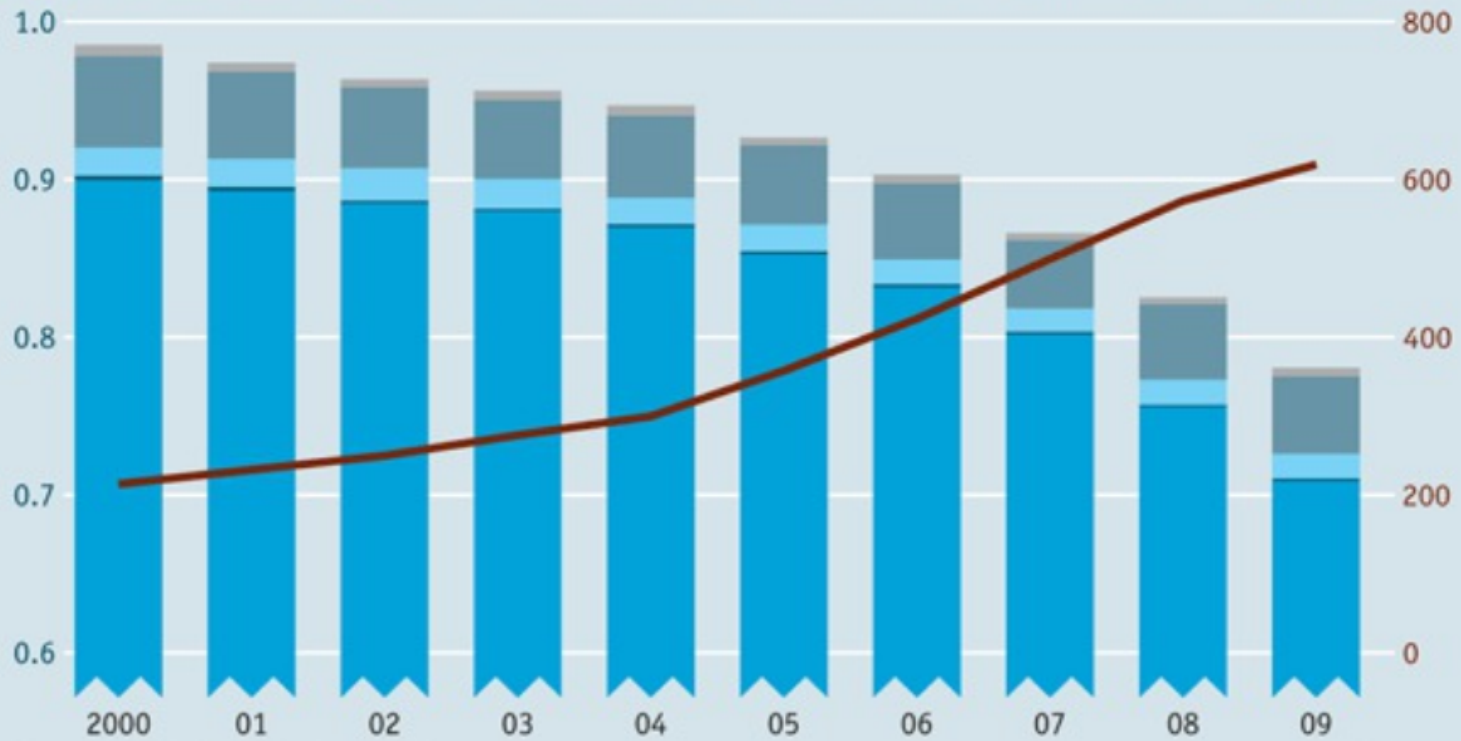
Global malaria deaths and R&D funding

Global malaria deaths*, m

Africa Americas Eastern Mediterranean South-East Asia Western Pacific

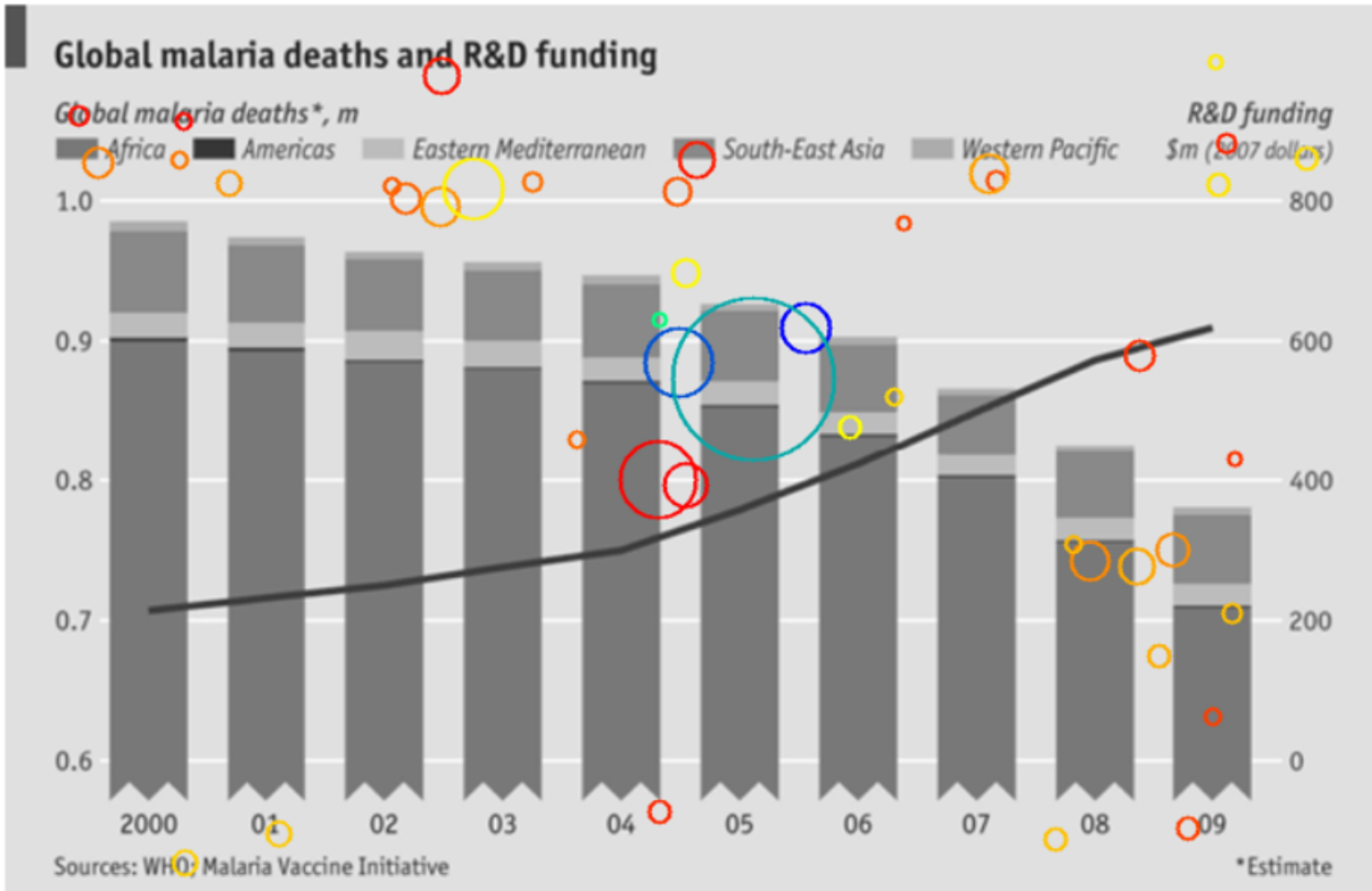
R&D funding

\$m (2007 dollars)



Sources: WHO; Malaria Vaccine Initiative

*Estimate



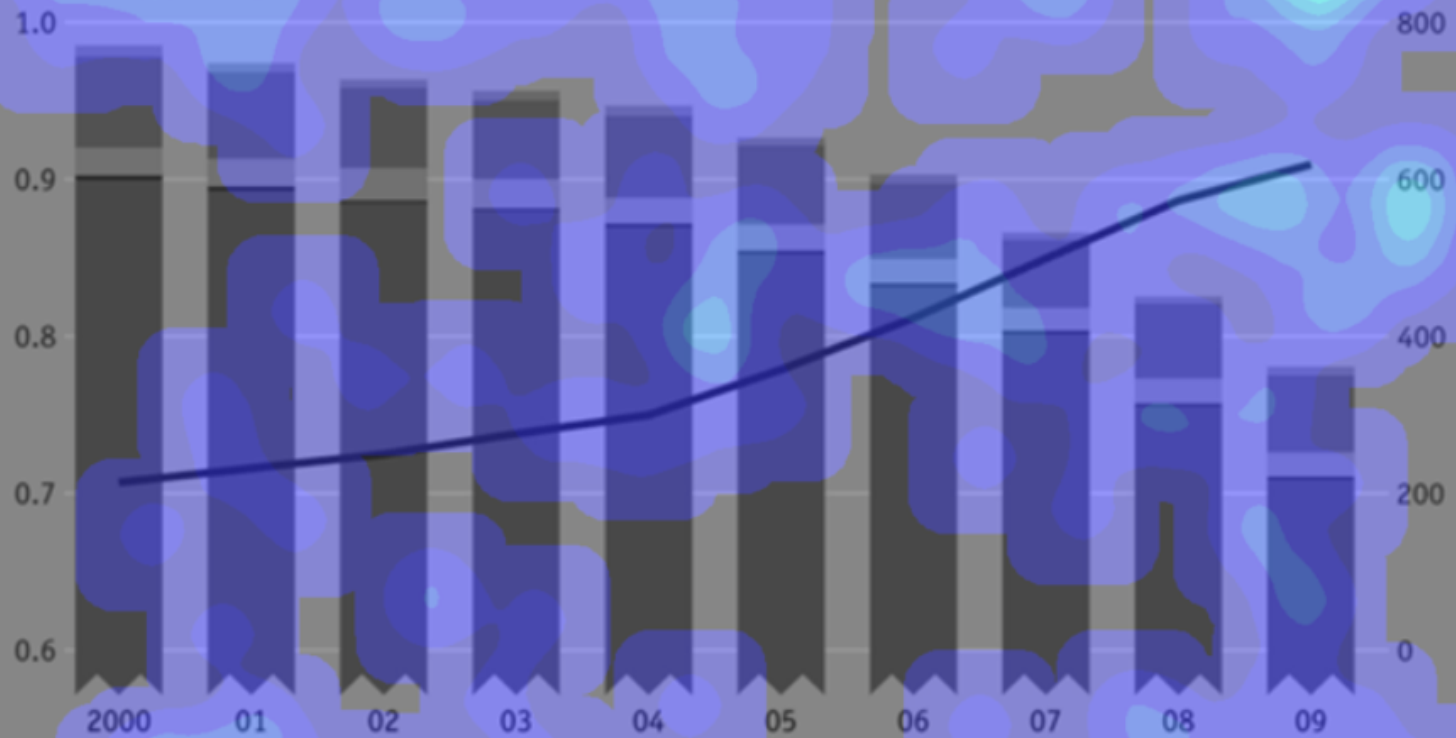
Global malaria deaths and R&D funding

Global malaria deaths*, m

Africa Americas Eastern Mediterranean South-East Asia Western Pacific

R&D funding

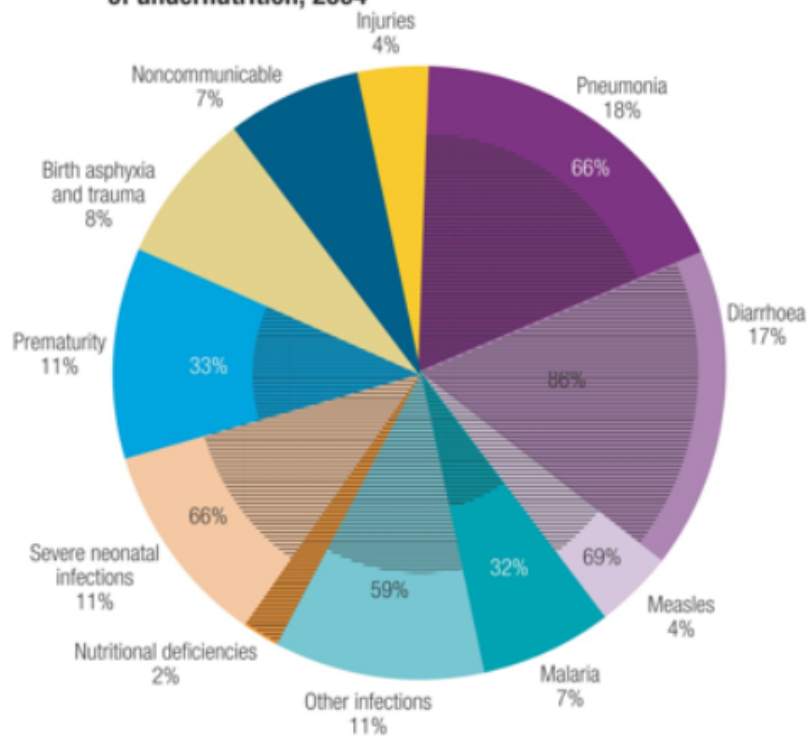
\$m (2007 dollars)



Sources: WHO; Malaria Vaccine Initiative

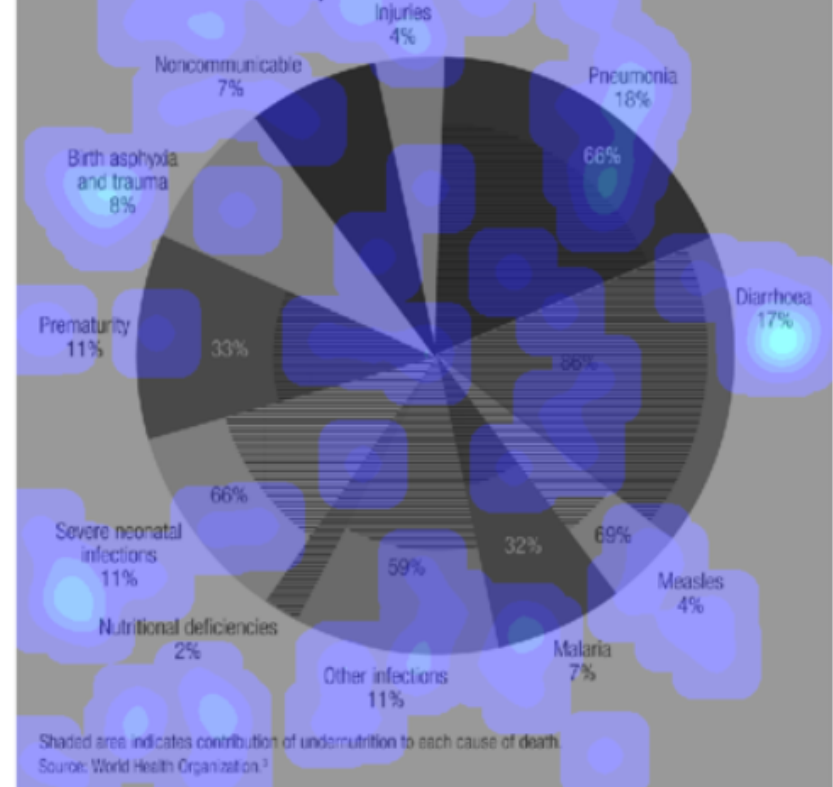
*Estimate

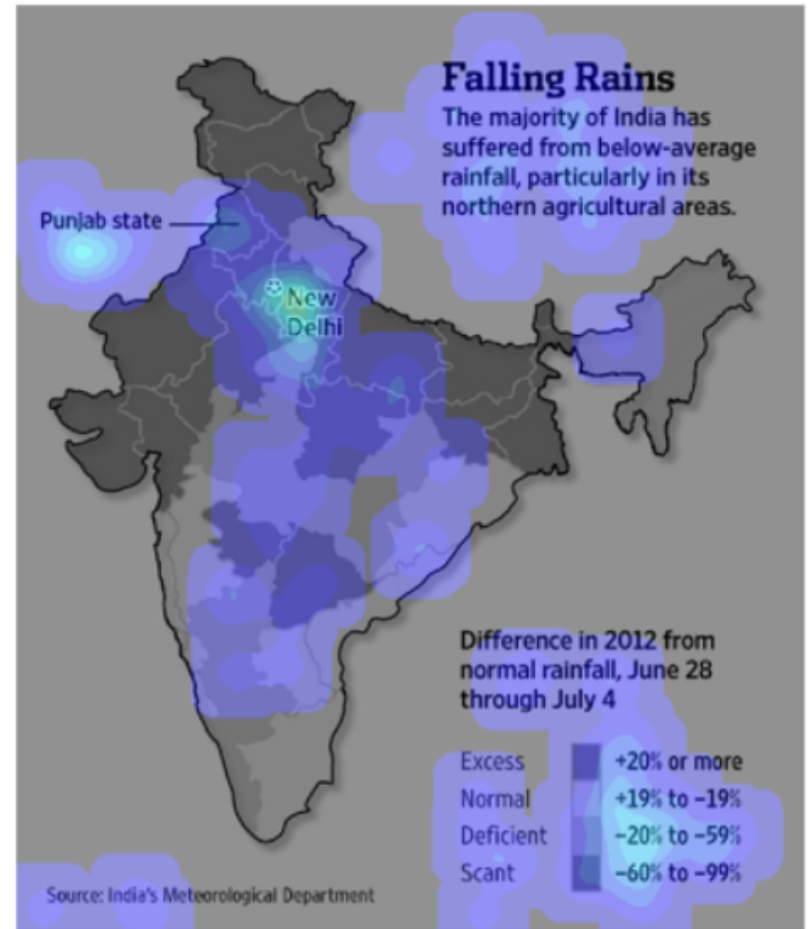
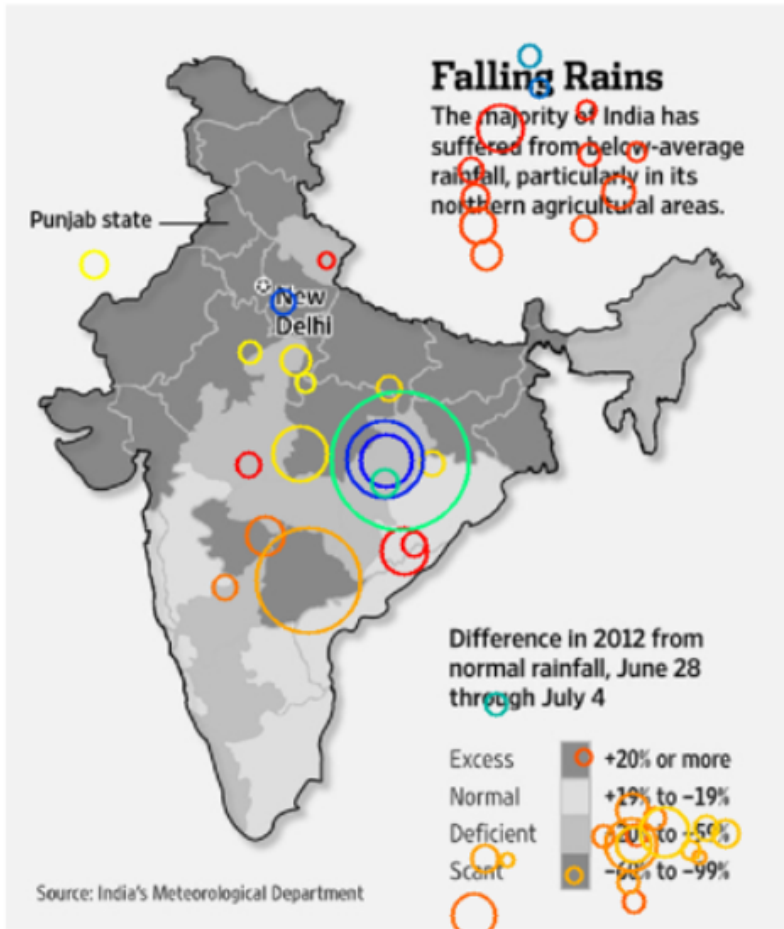
Figure 2 Distribution of major causes of death in girls under five years of age, including disease-specific contribution of undernutrition, 2004



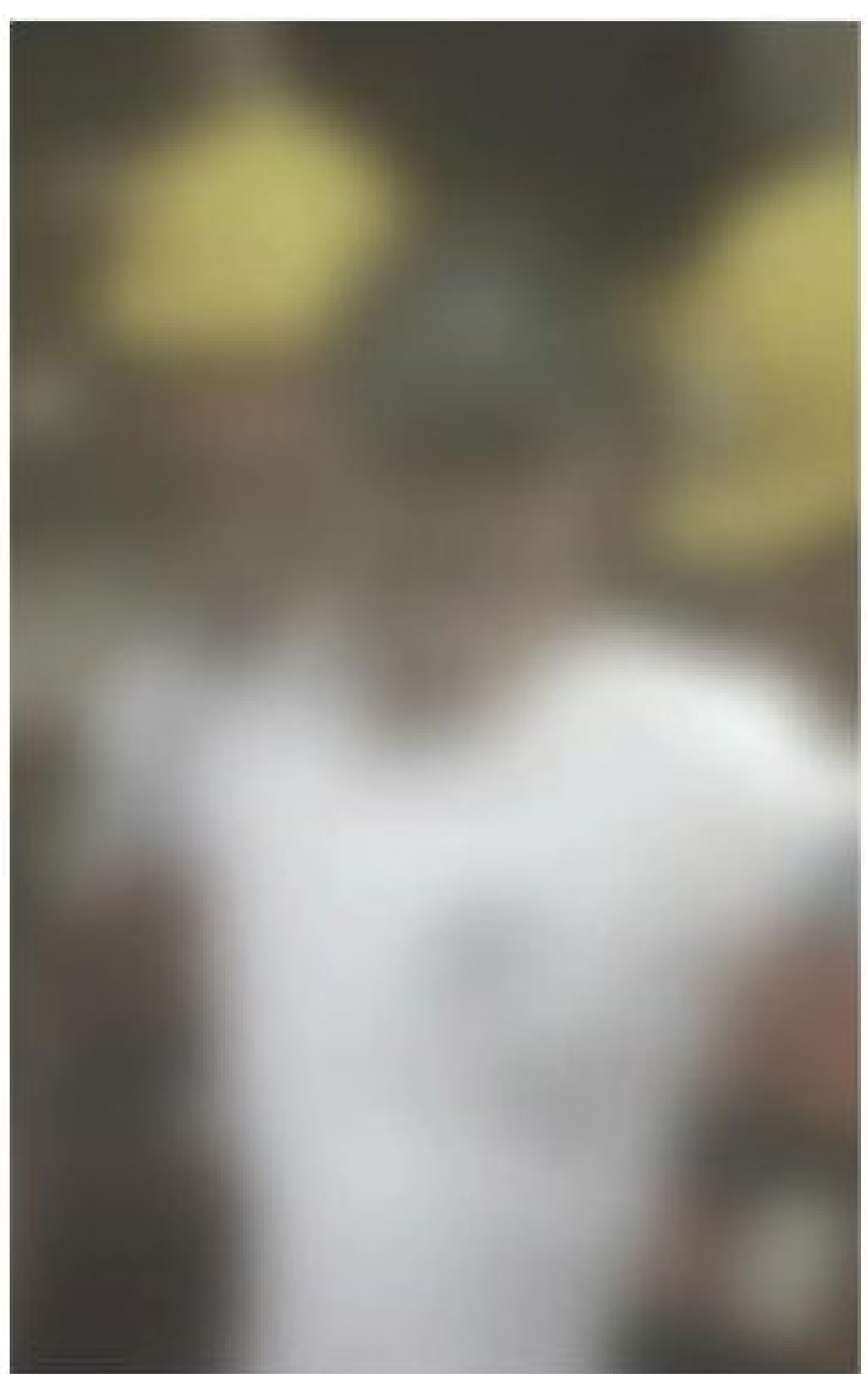
Shaded area indicates contribution of undernutrition to each cause of death.
Source: World Health Organization.²

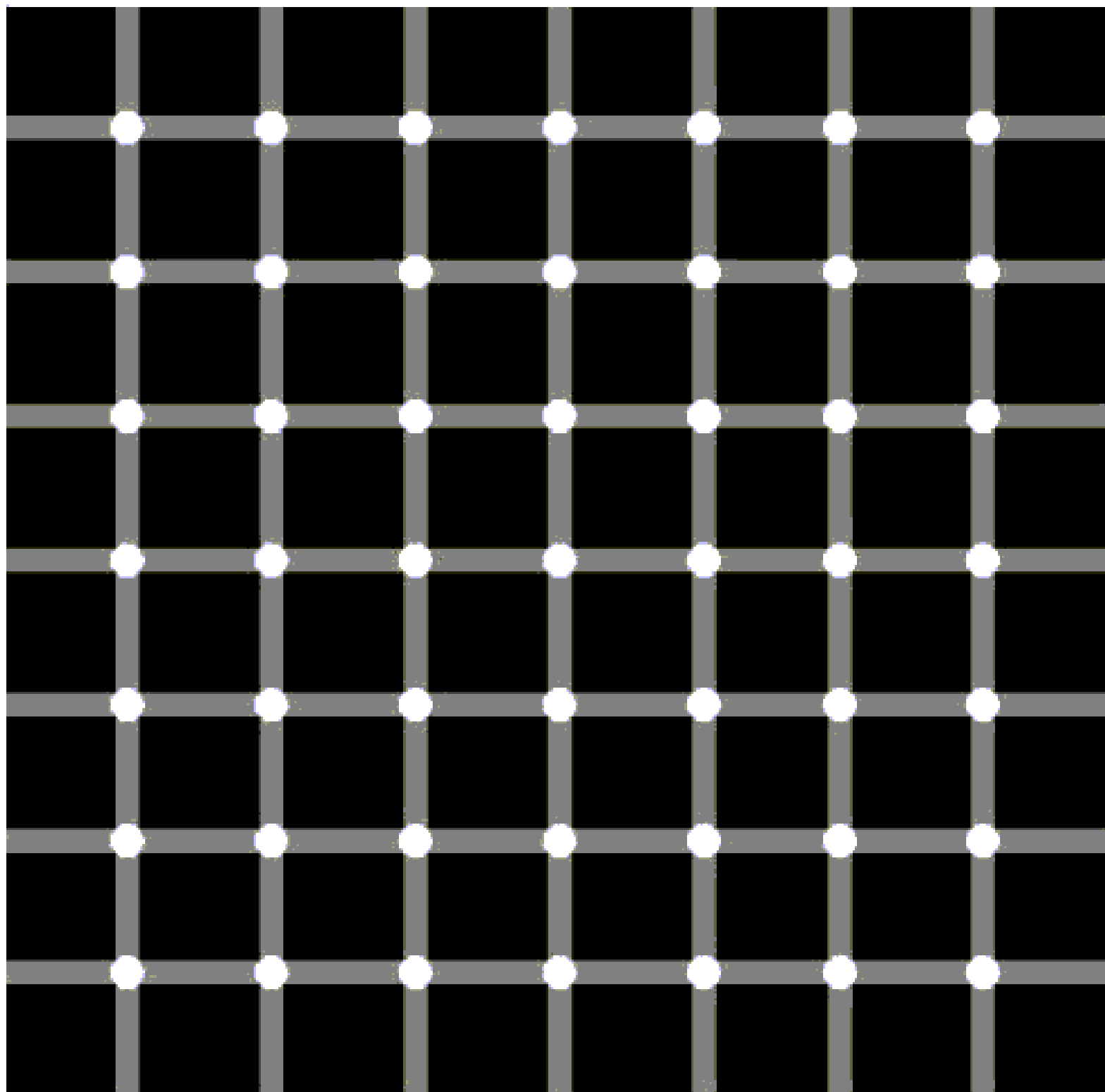
Figure 2 Distribution of major causes of death in girls under five years of age, including disease-specific contribution of undernutrition, 2004

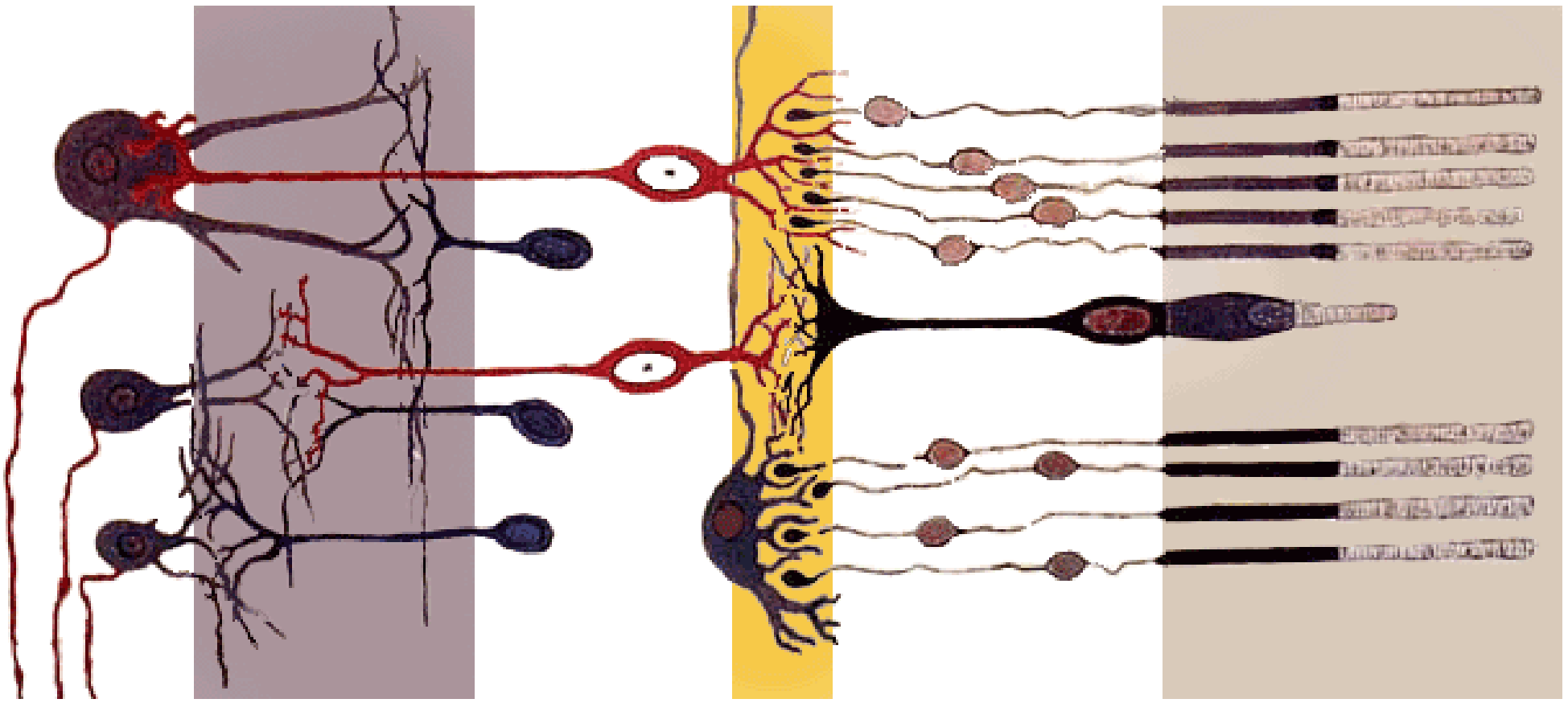




Year	2010	2011	2012	2013	2014
Revenue	1,000,000	1,100,000	1,200,000	1,300,000	1,400,000
Expenses	800,000	850,000	900,000	950,000	1,000,000
Profit	200,000	250,000	300,000	350,000	400,000
Profit Margin	20.0%	22.7%	25.0%	26.9%	28.6%
Revenue	1,500,000	1,600,000	1,700,000	1,800,000	1,900,000
Expenses	1,200,000	1,300,000	1,400,000	1,500,000	1,600,000
Profit	300,000	300,000	300,000	300,000	300,000
Profit Margin	20.0%	18.8%	17.6%	16.7%	15.8%
Revenue	2,000,000	2,100,000	2,200,000	2,300,000	2,400,000
Expenses	1,500,000	1,600,000	1,700,000	1,800,000	1,900,000
Profit	500,000	500,000	500,000	500,000	500,000
Profit Margin	25.0%	23.8%	22.7%	21.7%	20.8%
Revenue	2,500,000	2,600,000	2,700,000	2,800,000	2,900,000
Expenses	1,800,000	1,900,000	2,000,000	2,100,000	2,200,000
Profit	700,000	700,000	700,000	700,000	700,000
Profit Margin	28.0%	26.9%	25.9%	25.0%	24.1%
Revenue	3,000,000	3,100,000	3,200,000	3,300,000	3,400,000
Expenses	2,200,000	2,300,000	2,400,000	2,500,000	2,600,000
Profit	800,000	800,000	800,000	800,000	800,000
Profit Margin	26.7%	25.8%	25.0%	24.1%	23.5%
Revenue	3,500,000	3,600,000	3,700,000	3,800,000	3,900,000
Expenses	2,500,000	2,600,000	2,700,000	2,800,000	2,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	28.6%	27.8%	27.0%	26.3%	25.6%
Revenue	4,000,000	4,100,000	4,200,000	4,300,000	4,400,000
Expenses	3,000,000	3,100,000	3,200,000	3,300,000	3,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	25.0%	24.4%	23.8%	23.3%	22.7%
Revenue	4,500,000	4,600,000	4,700,000	4,800,000	4,900,000
Expenses	3,500,000	3,600,000	3,700,000	3,800,000	3,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	22.2%	21.7%	21.3%	20.8%	20.4%
Revenue	5,000,000	5,100,000	5,200,000	5,300,000	5,400,000
Expenses	4,000,000	4,100,000	4,200,000	4,300,000	4,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	20.0%	19.6%	19.2%	18.9%	18.5%
Revenue	5,500,000	5,600,000	5,700,000	5,800,000	5,900,000
Expenses	4,500,000	4,600,000	4,700,000	4,800,000	4,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	18.2%	17.9%	17.5%	17.2%	16.8%
Revenue	6,000,000	6,100,000	6,200,000	6,300,000	6,400,000
Expenses	5,000,000	5,100,000	5,200,000	5,300,000	5,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	16.7%	16.4%	16.1%	15.8%	15.6%
Revenue	6,500,000	6,600,000	6,700,000	6,800,000	6,900,000
Expenses	5,500,000	5,600,000	5,700,000	5,800,000	5,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	15.4%	15.2%	15.0%	14.8%	14.6%
Revenue	7,000,000	7,100,000	7,200,000	7,300,000	7,400,000
Expenses	6,000,000	6,100,000	6,200,000	6,300,000	6,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	14.3%	14.1%	13.9%	13.7%	13.5%
Revenue	7,500,000	7,600,000	7,700,000	7,800,000	7,900,000
Expenses	6,500,000	6,600,000	6,700,000	6,800,000	6,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	13.3%	13.2%	13.1%	13.0%	12.9%
Revenue	8,000,000	8,100,000	8,200,000	8,300,000	8,400,000
Expenses	7,000,000	7,100,000	7,200,000	7,300,000	7,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	12.5%	12.4%	12.3%	12.2%	12.1%
Revenue	8,500,000	8,600,000	8,700,000	8,800,000	8,900,000
Expenses	7,500,000	7,600,000	7,700,000	7,800,000	7,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	11.8%	11.6%	11.5%	11.4%	11.3%
Revenue	9,000,000	9,100,000	9,200,000	9,300,000	9,400,000
Expenses	8,000,000	8,100,000	8,200,000	8,300,000	8,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	11.1%	11.0%	10.9%	10.8%	10.7%
Revenue	9,500,000	9,600,000	9,700,000	9,800,000	9,900,000
Expenses	8,500,000	8,600,000	8,700,000	8,800,000	8,900,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	10.5%	10.4%	10.3%	10.2%	10.1%
Revenue	10,000,000	10,100,000	10,200,000	10,300,000	10,400,000
Expenses	9,000,000	9,100,000	9,200,000	9,300,000	9,400,000
Profit	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Profit Margin	10.0%	9.9%	9.8%	9.7%	9.6%

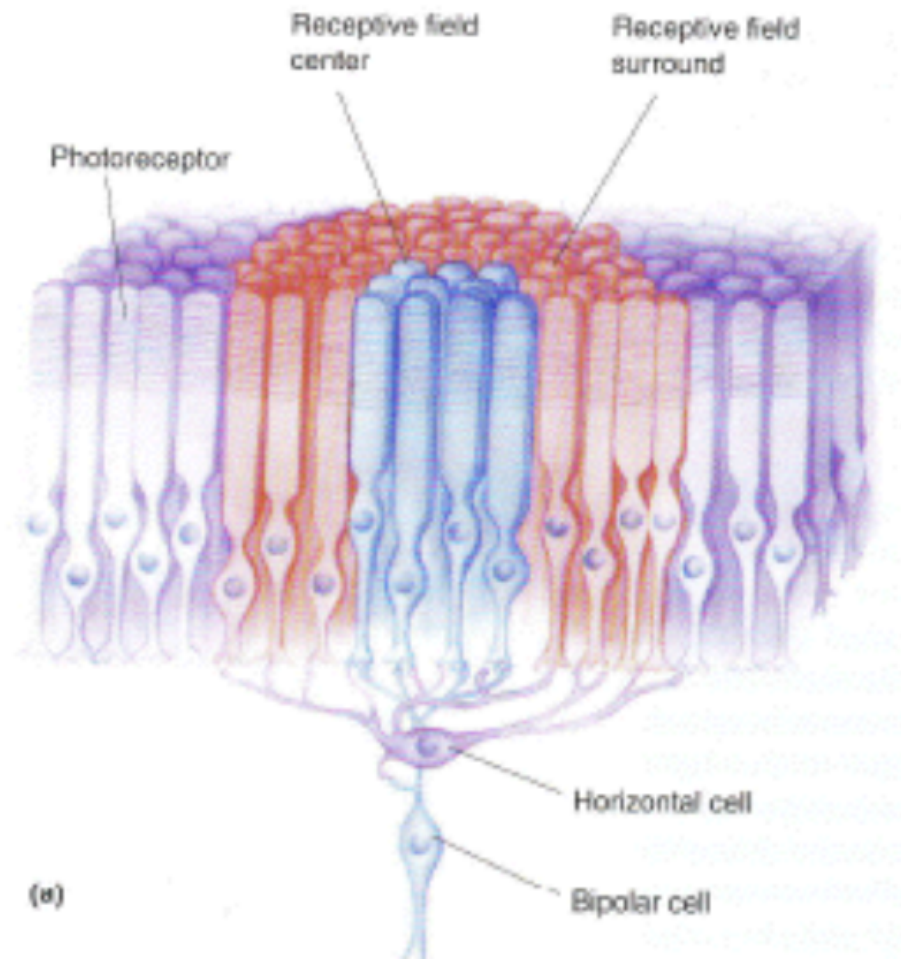






Center-Surround Organization

~126 Million
Rods and Cones



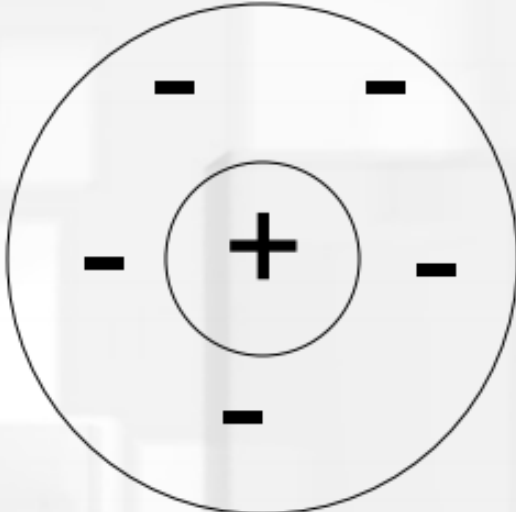
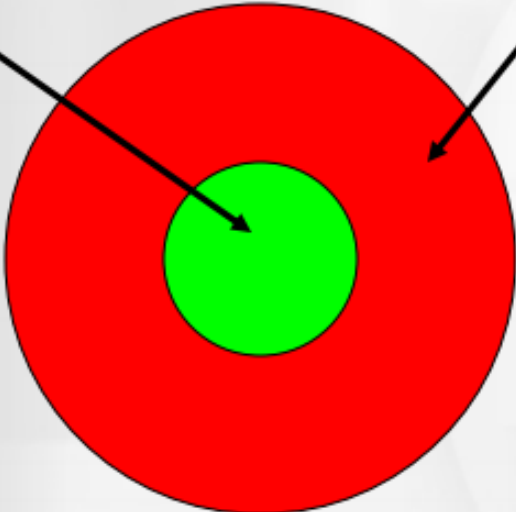
Massive compression!

~1 Million
Ganglion Cells &
Optical Nerve Fibers

Center/Surround organization of a receptive field

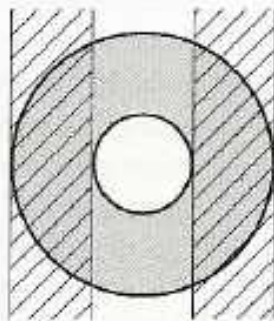
Excitatory center

Inhibitory surround



Stimulus situation

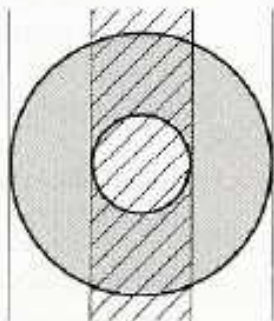
a. White stripe on a dark background



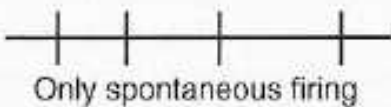
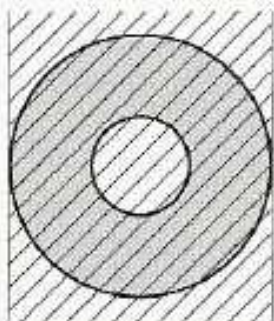
Ganglion cell firing rate



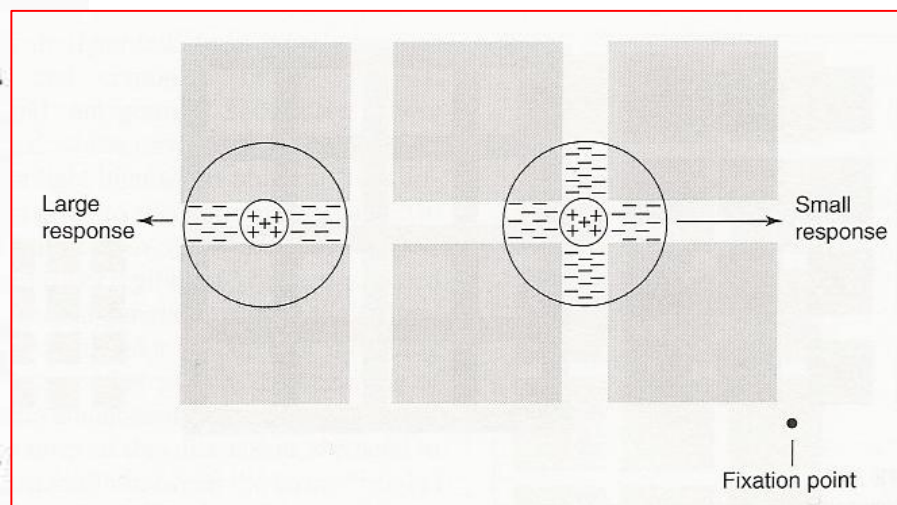
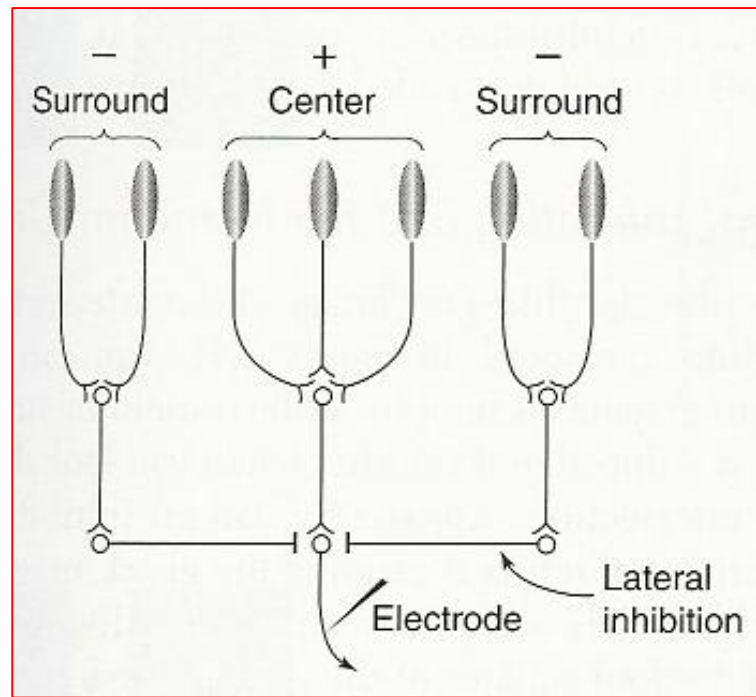
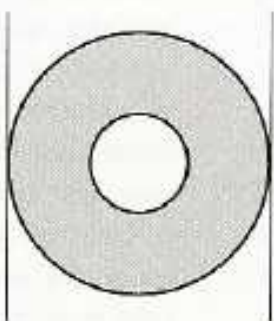
b. Dark stripe on a white background



c. Completely dark field

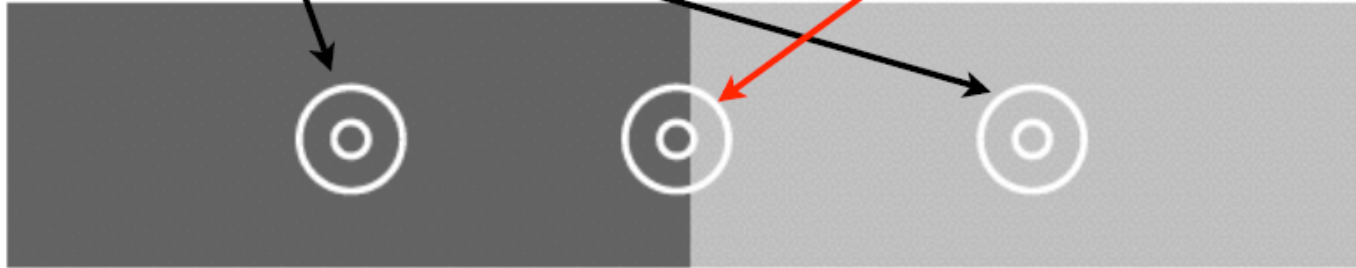


d. Completely light field



Low Activity
Center and surrounds cancel

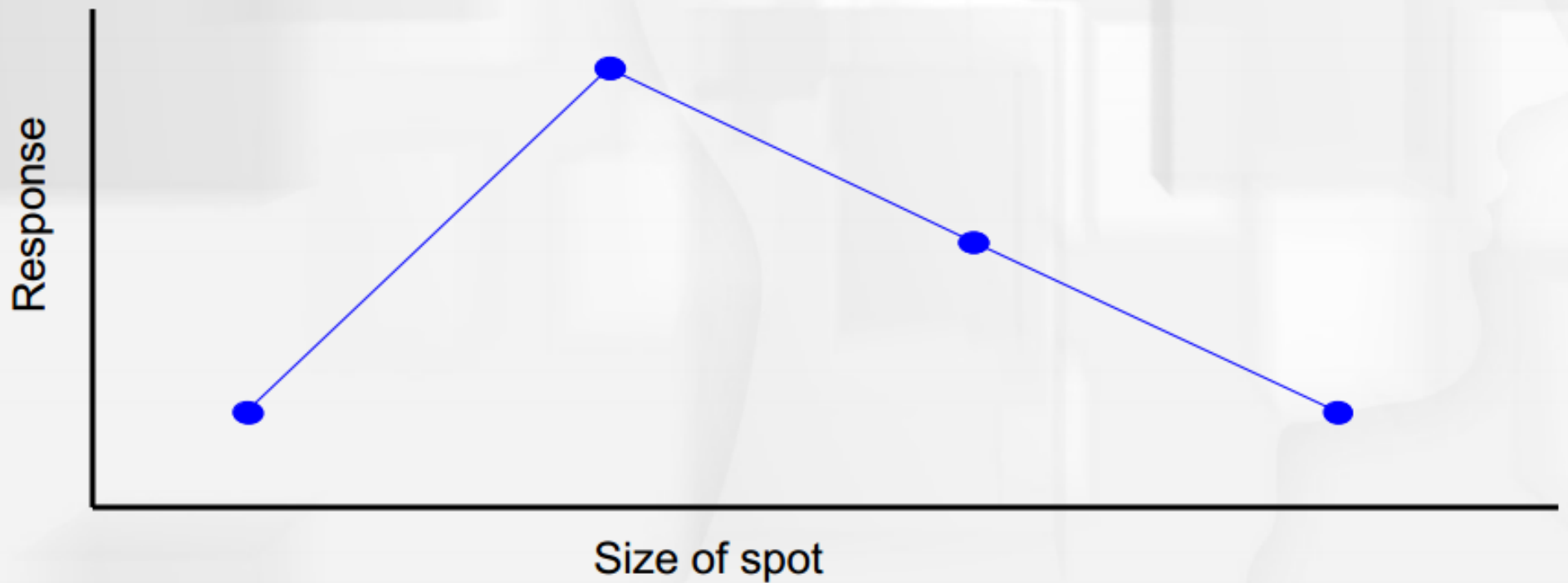
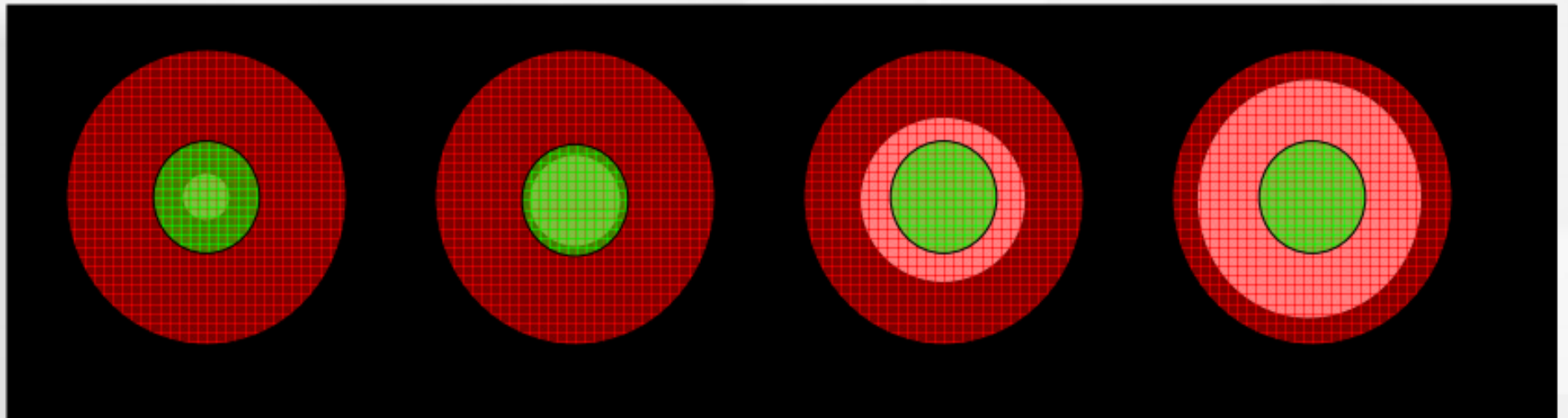
Activity increased
or decreased at edges



luminance L

$\frac{dL}{dx}$

Center/Surround cells 'prefer' spots of light of a particular size

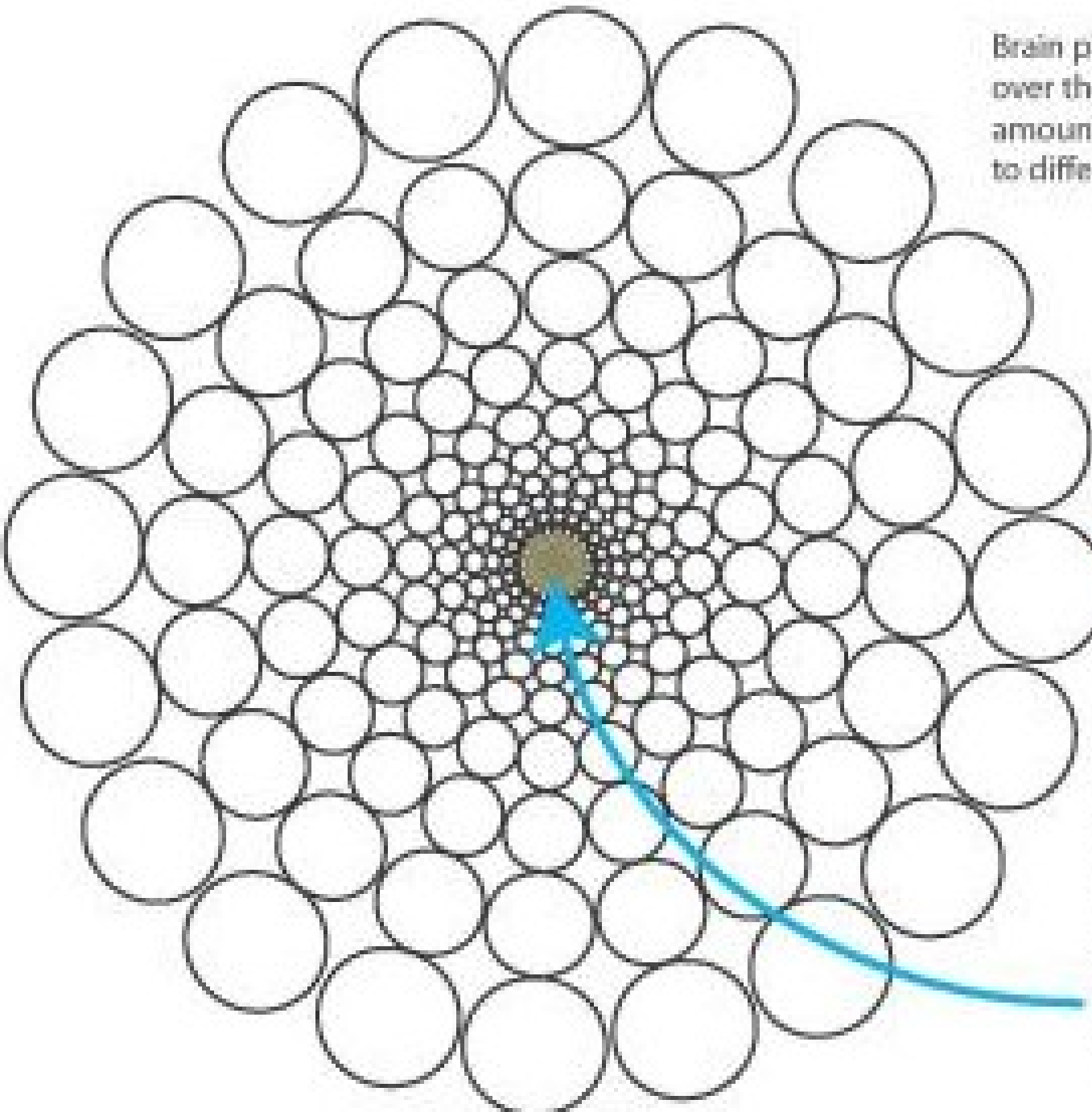


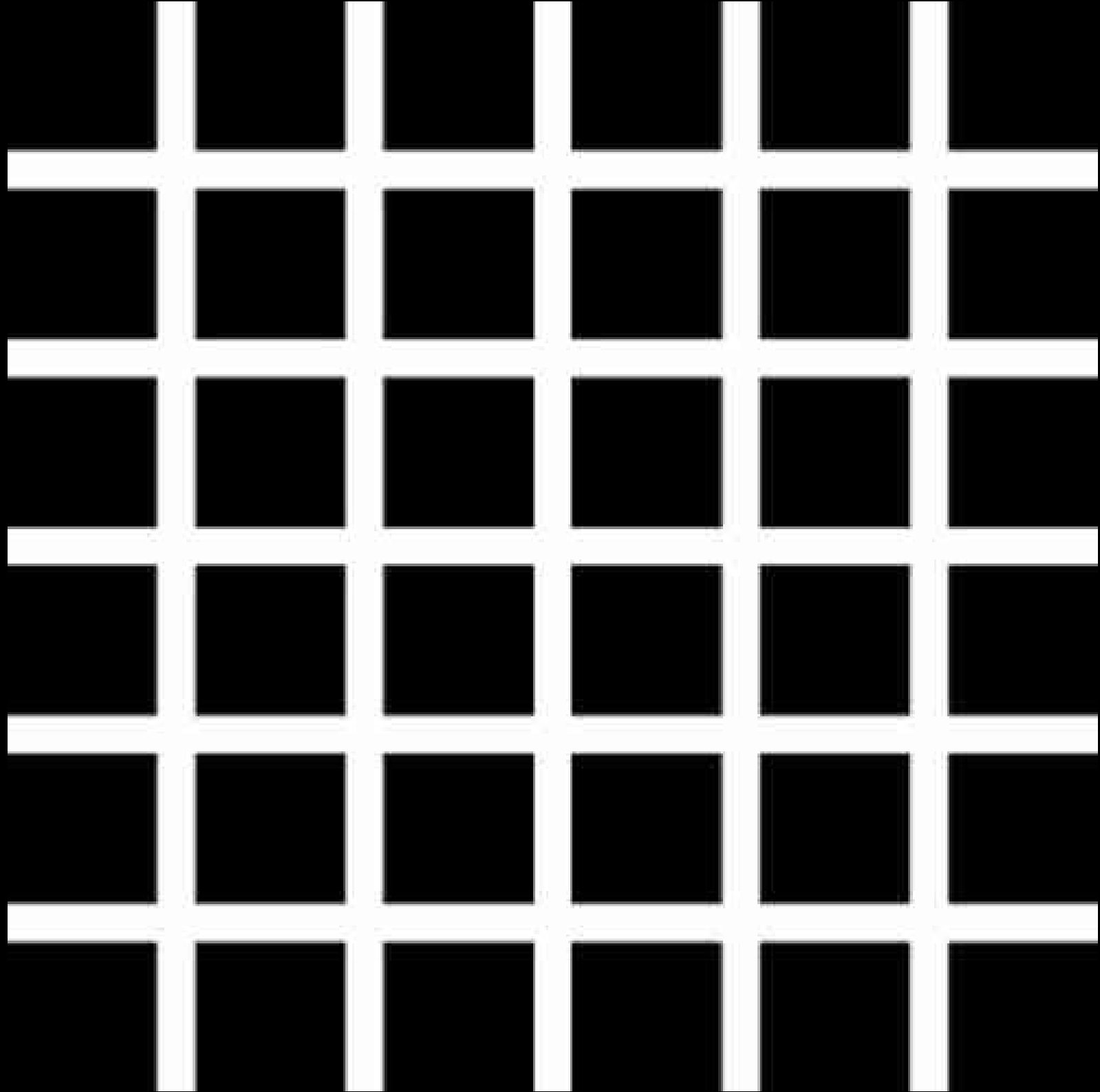
Brain pixels vary enormously in size over the visual field. This reflects differing amounts of neural processing power devoted to different regions of visual space.

At the edge of the visual field we can only barely see something the size of a fist at arm's length.

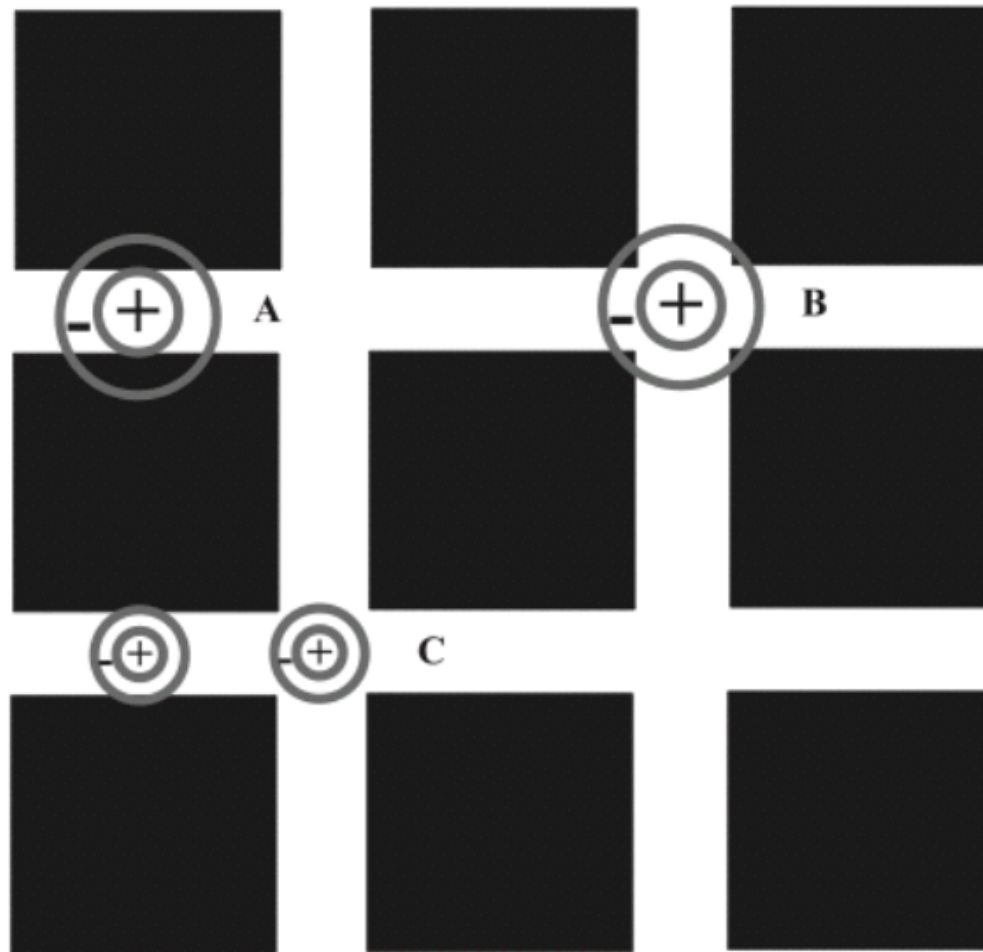
We can resolve about 100 points on the head of a pin held at arm's length in the very center of the visual field called the fovea.

Over half of our visual processing power is concentrated in a slightly larger area called the parafovea.





Hermann Grid Effect



Cornsweet illusion

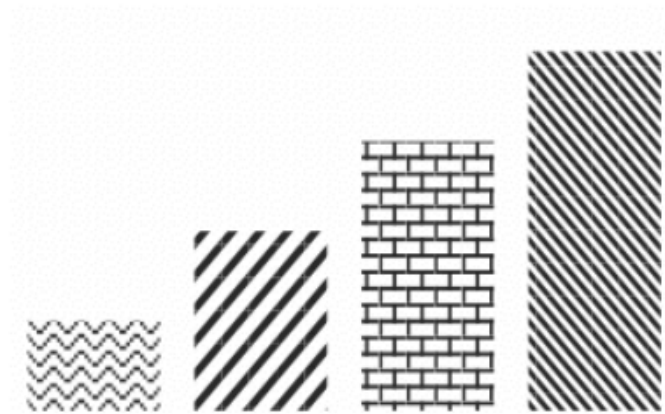


Cornsweet illusion

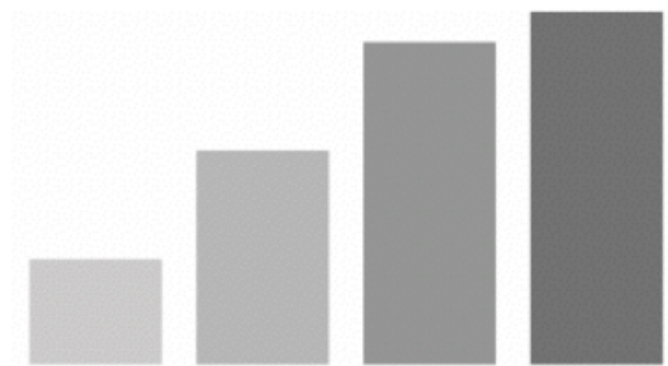




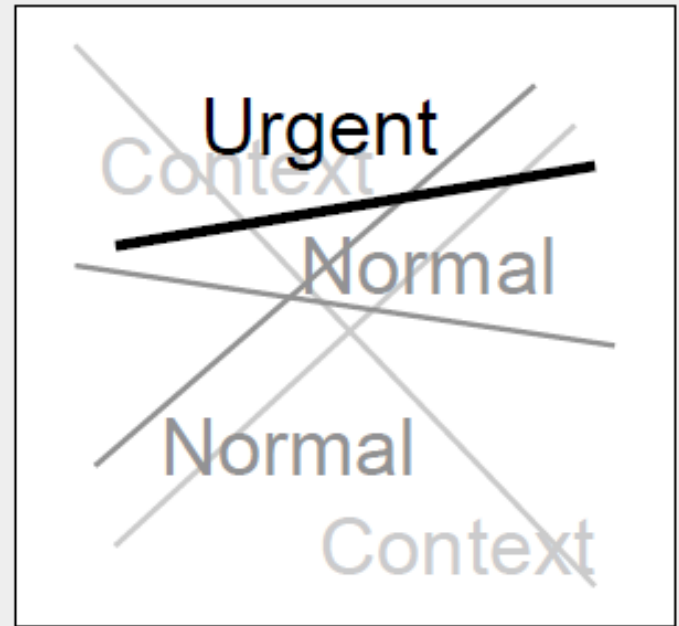
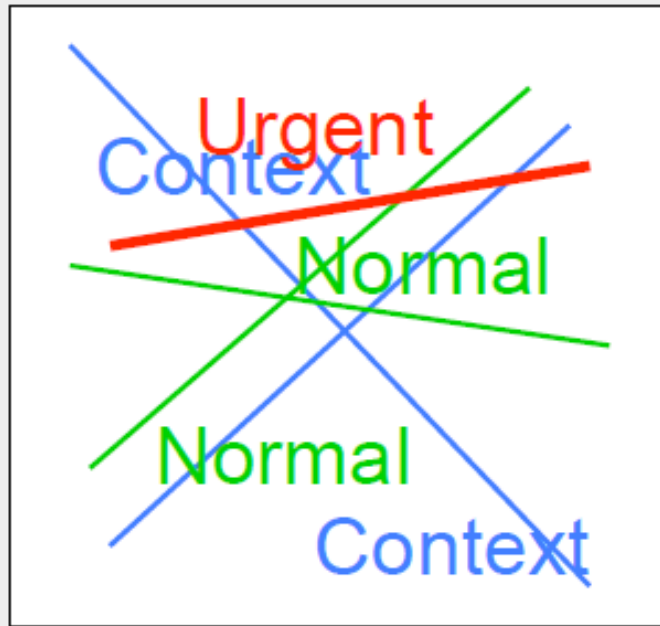
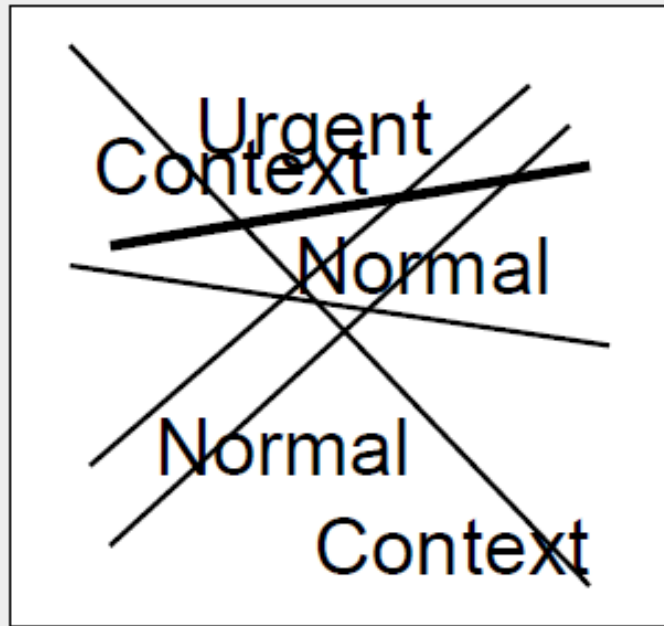
- Visual system:
 - see differences, not absolute values
 - attracted by edges with high contrast
- recommendation
 - increase the contrast between visual elements
 - avoid engaging textures



V.S.

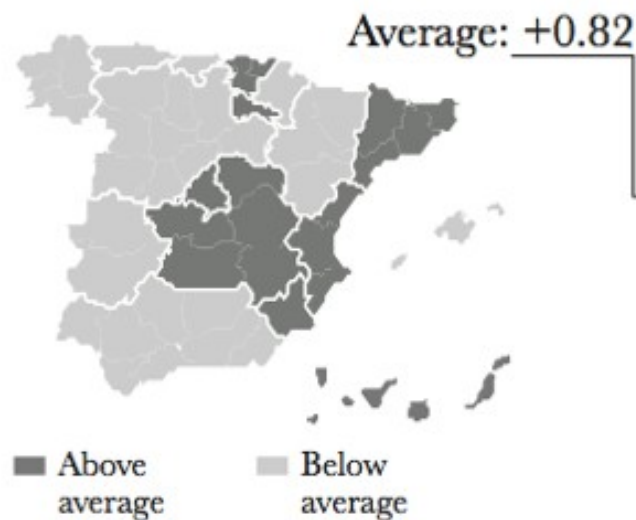


Contrast



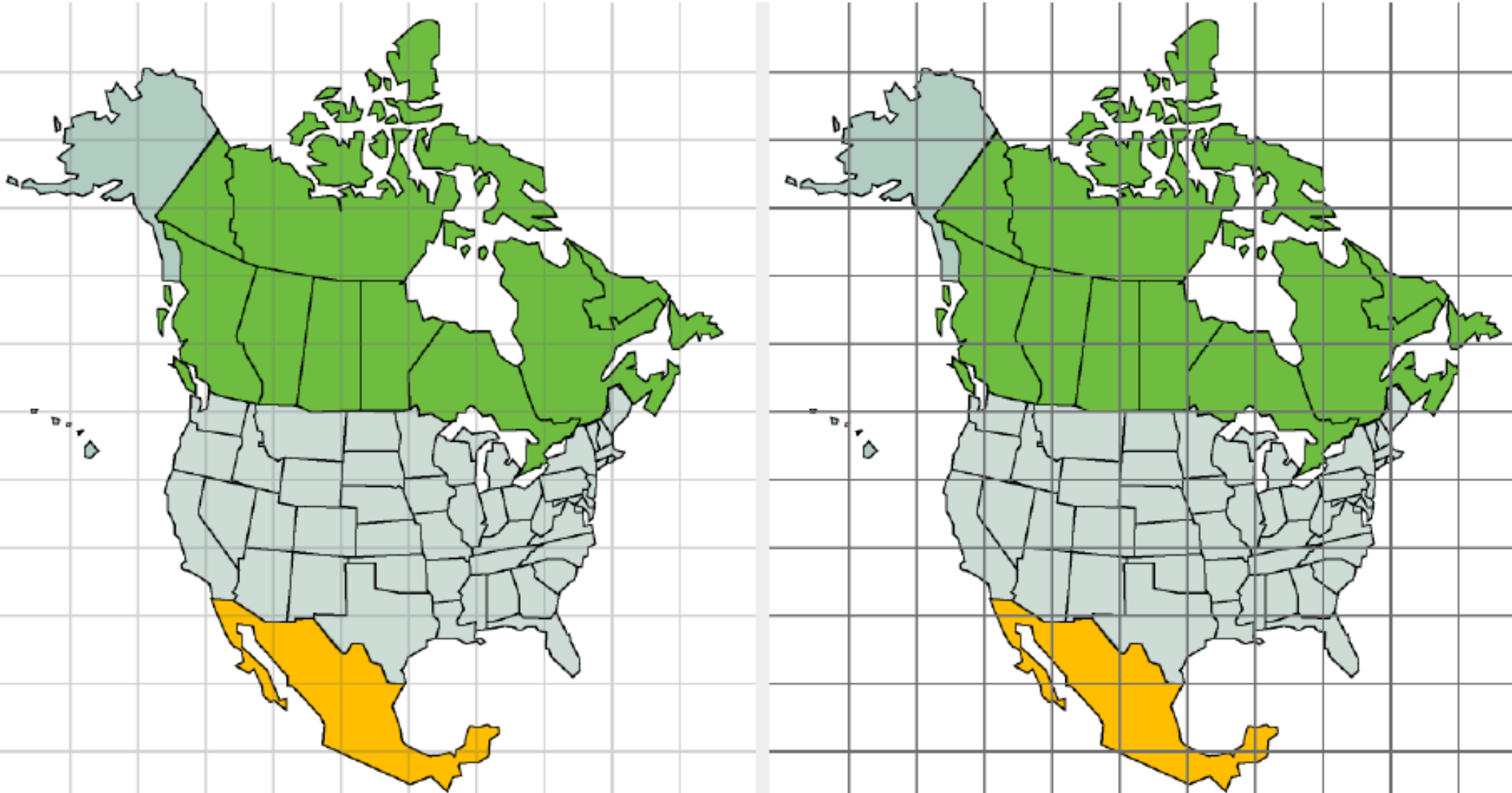
Unemployment rates by region (in October)

Percentage change compared to previous month



Canarias	+3.42
Aragón	+2.48
Madrid	+2.33
C. Valenciana	+2.08
Melilla	+1.93
Ceuta	+1.81
Murcia	+1.78
C.-La Mancha	+1.78
Cataluña	+1.39
La Rioja	+1.02
País Vasco	+0.84
C. y León	+0.77
Cantabria	+0.54
Navarra	+0.39
Andalucía	-0.30
Galicia	-0.39
Asturias	-0.82
Extremadura	-1.86
Baleares	-4.27

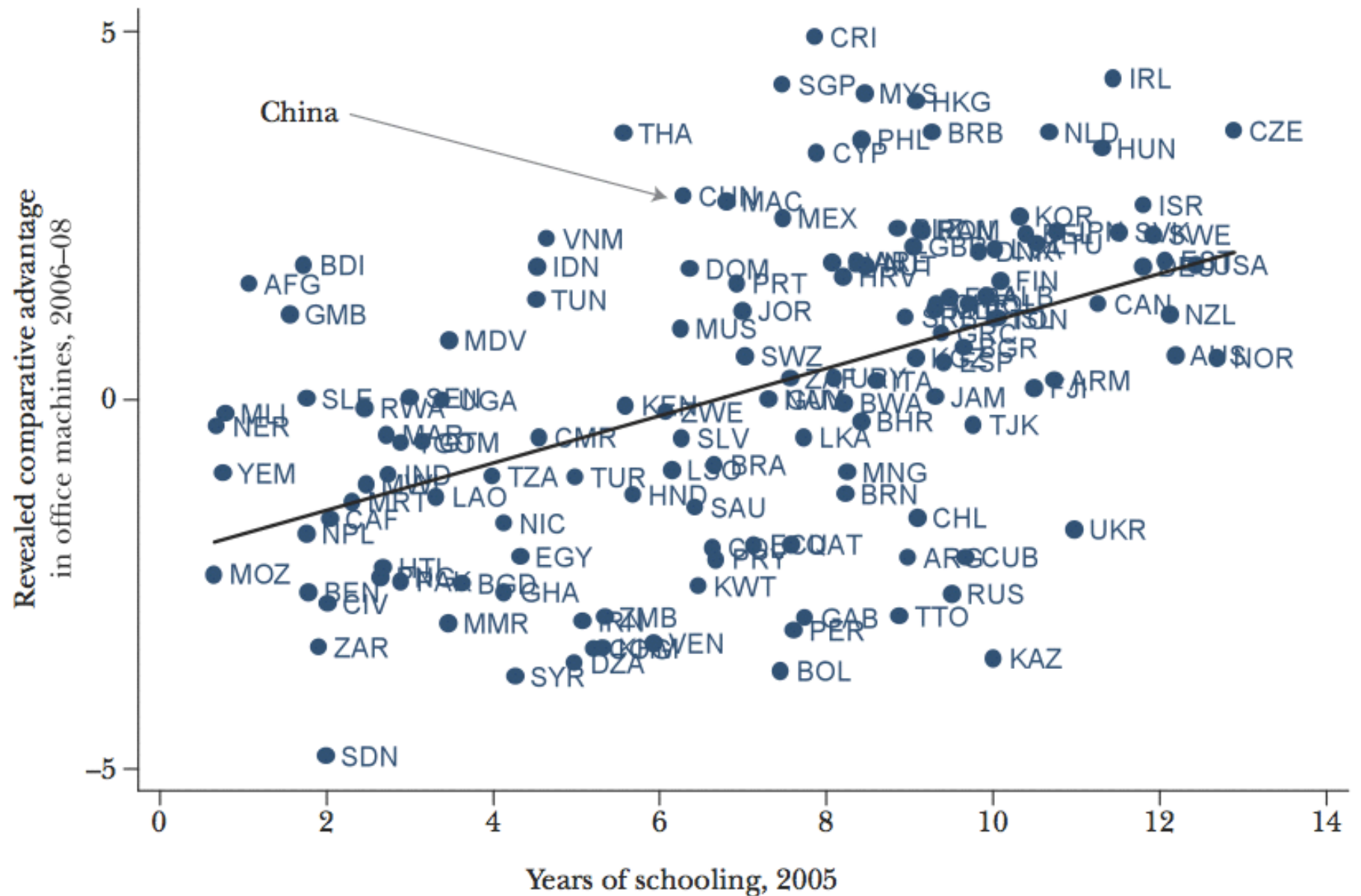
Contrast and layers



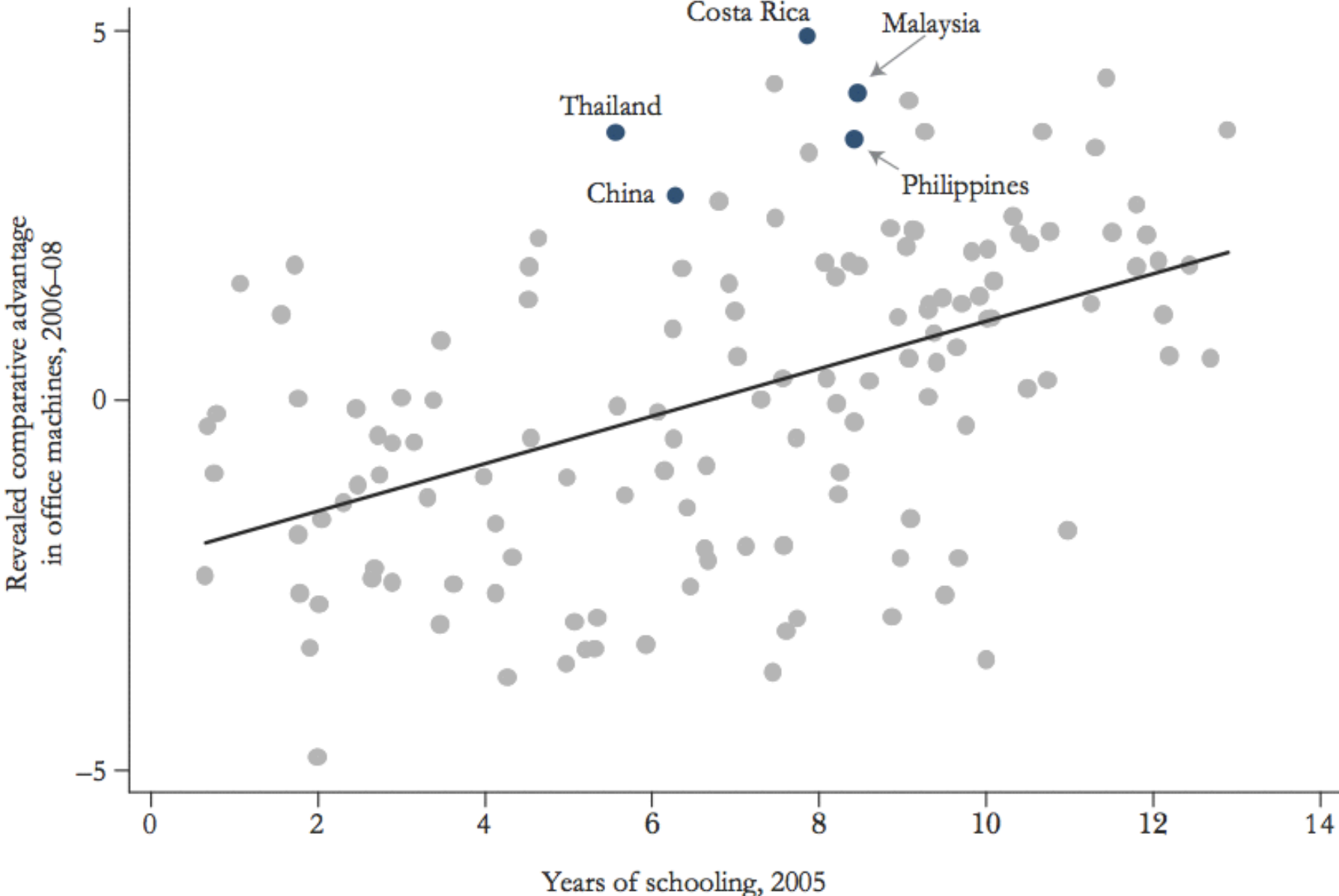
Mreža je u pozadini, malog je kontrasta

Mreža dominira slikom i ometa prikaz

Education and Exports of Office Machines

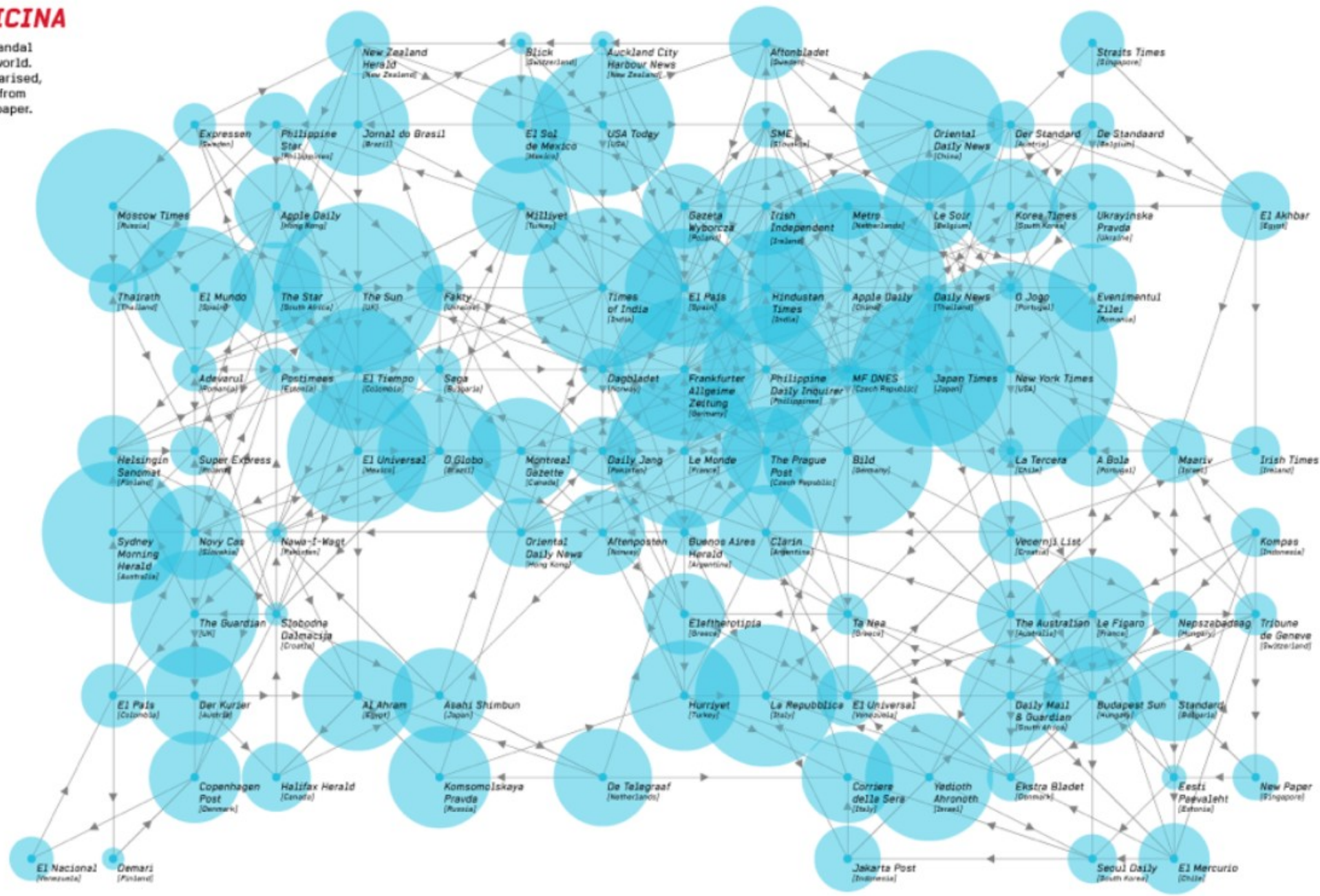


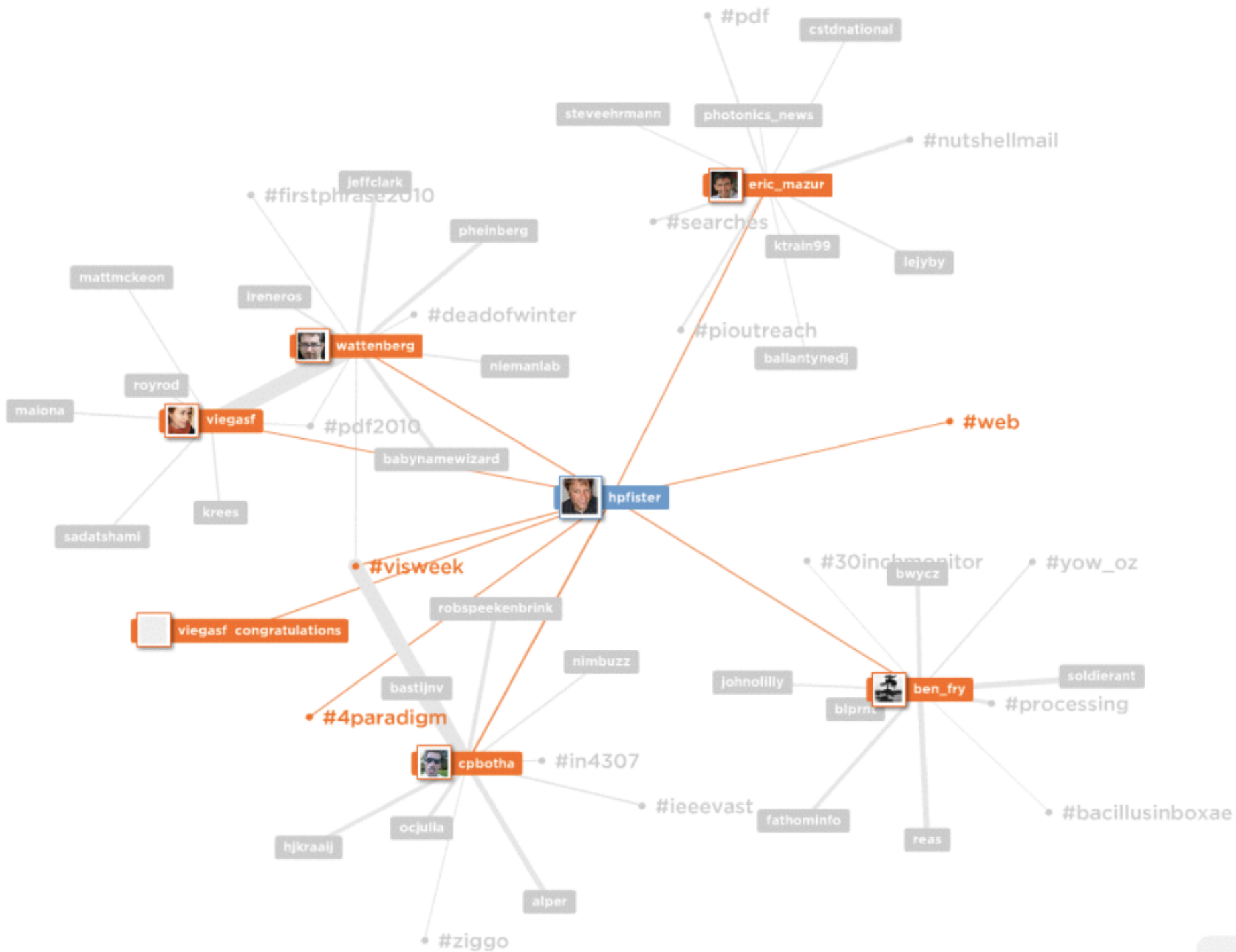
Education and Exports of Office Machines



SUMEDICINA

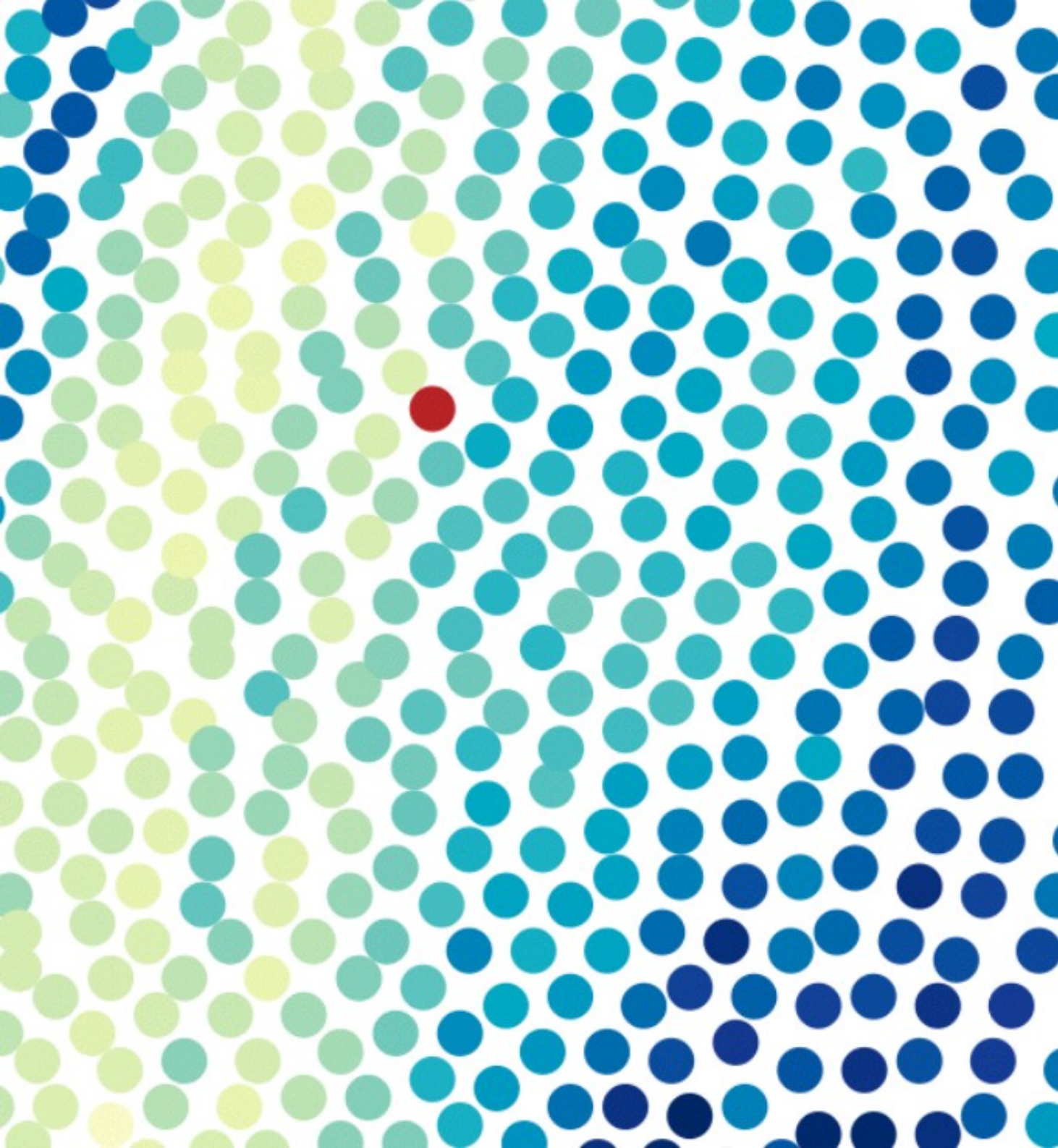
The Sumedicina scandal spread around the world. Everywhere rumors arised, which were passed from newspaper to newspaper.



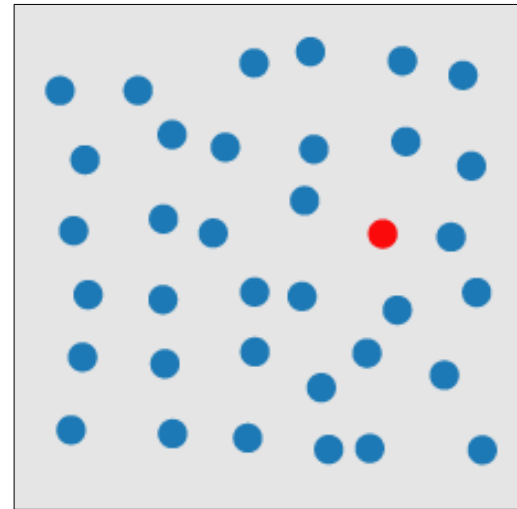
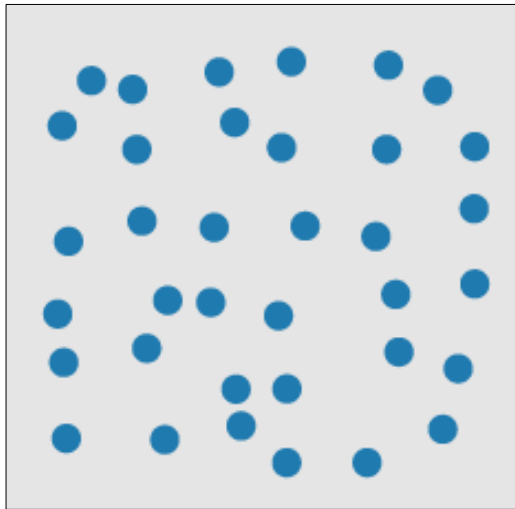


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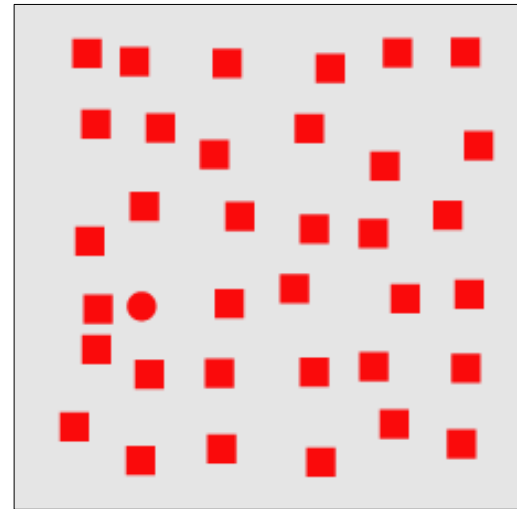
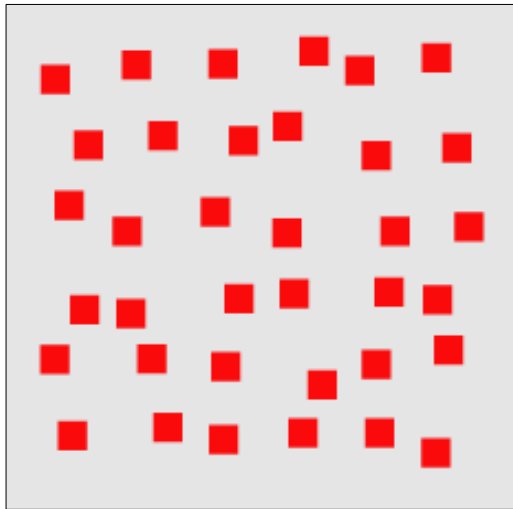
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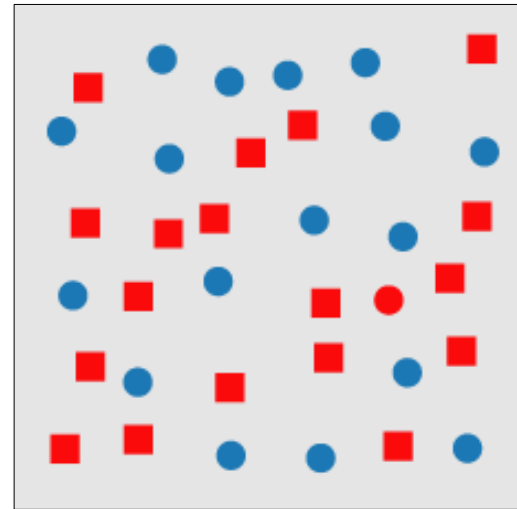
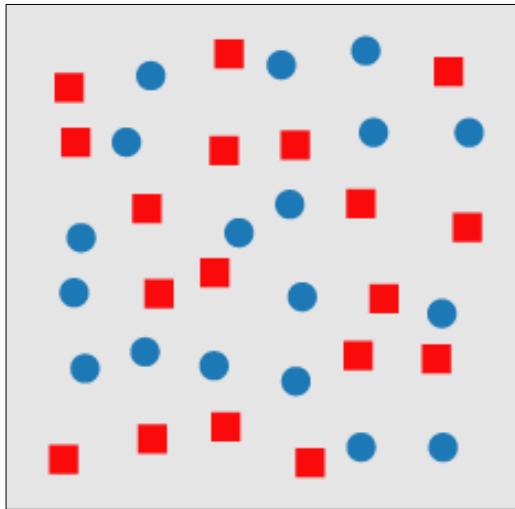
Color



Shape



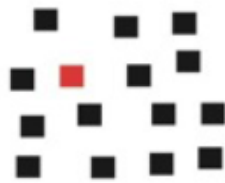
Color and shape



Basic Popout Channels

Color

hue



lightness

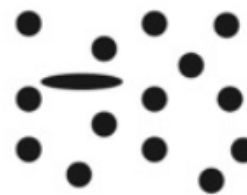


Elementary shape

size



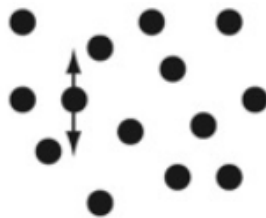
elongation



orientation



Motion

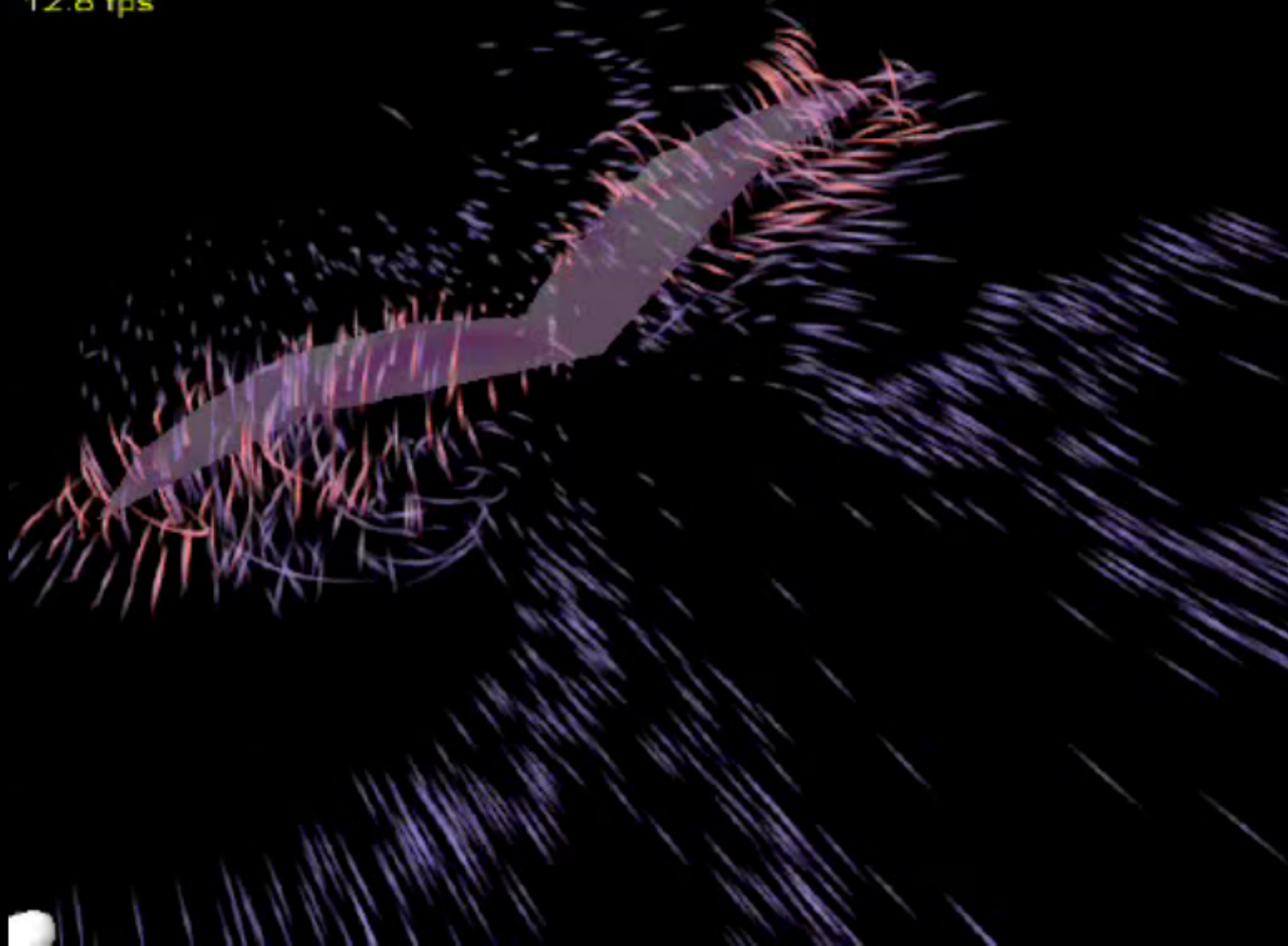


Spatial grouping



Motion

12.8 fps

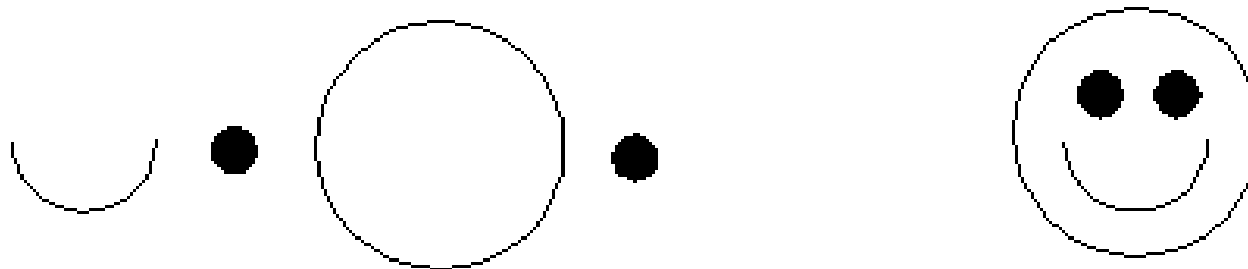




Gestalt Principles

Gestalt psychology – form psychology

- German: *gestalt* ~ form
- Rules of the organization of perceptual scenes
- Idera:
 - Perception of the whole is bigger than a sum of elements.



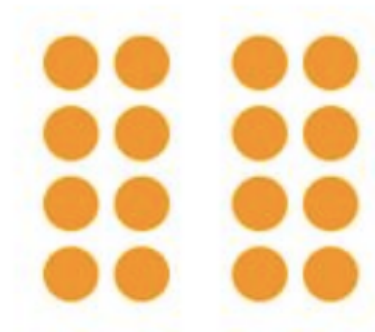
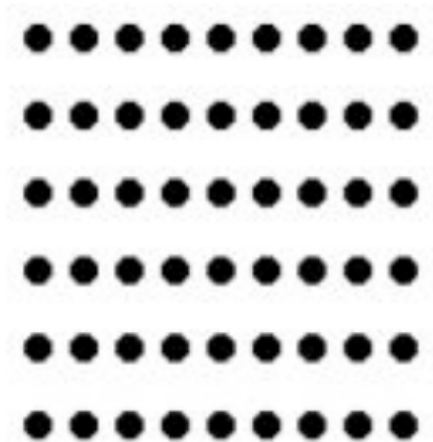
Similarity



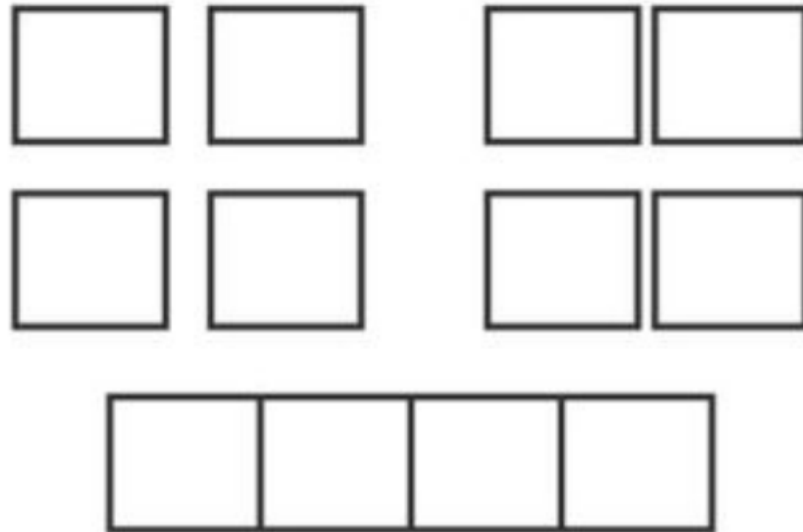
Similarity



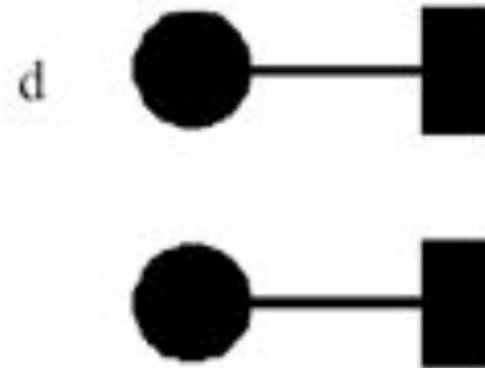
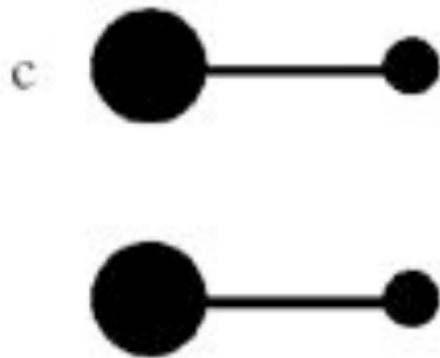
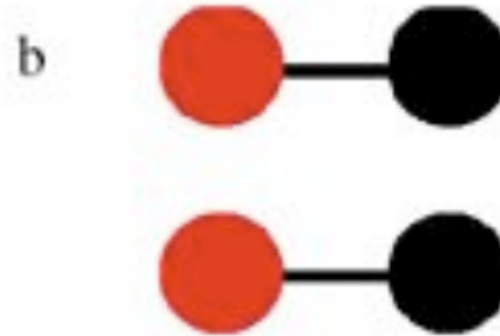
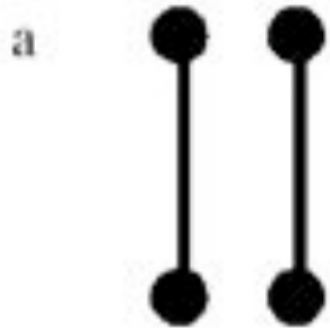
Proximity



Proximity

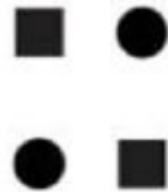


Connectedness



Grouping

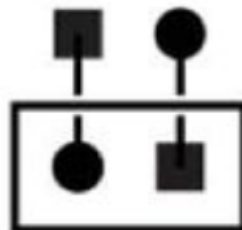
Similarity



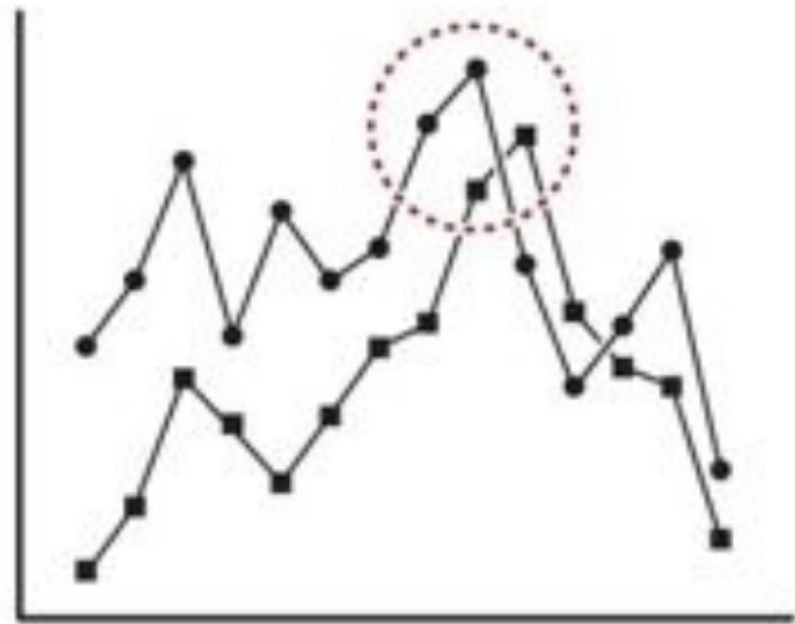
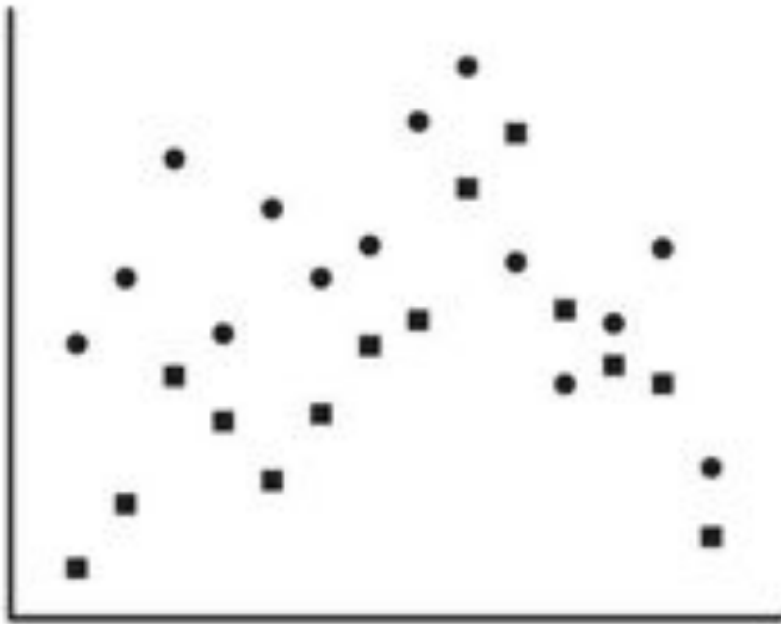
Connection



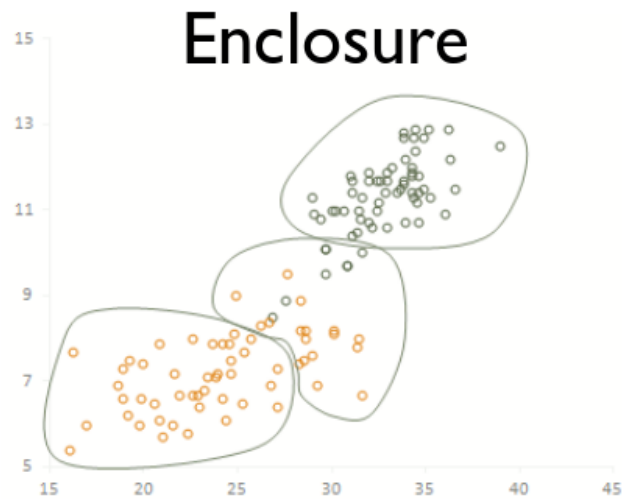
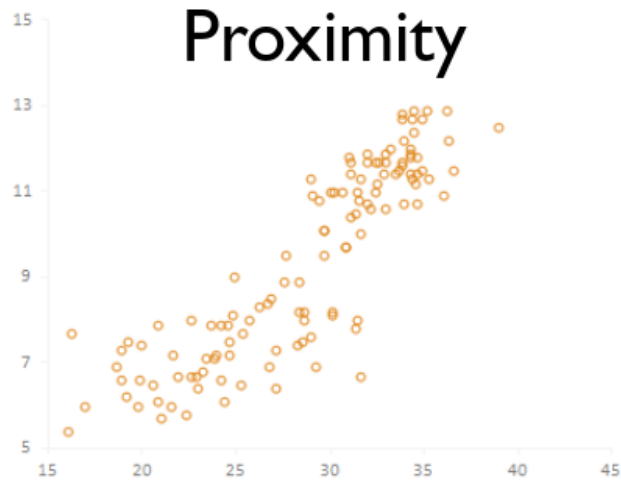
Enclosure



Grouping



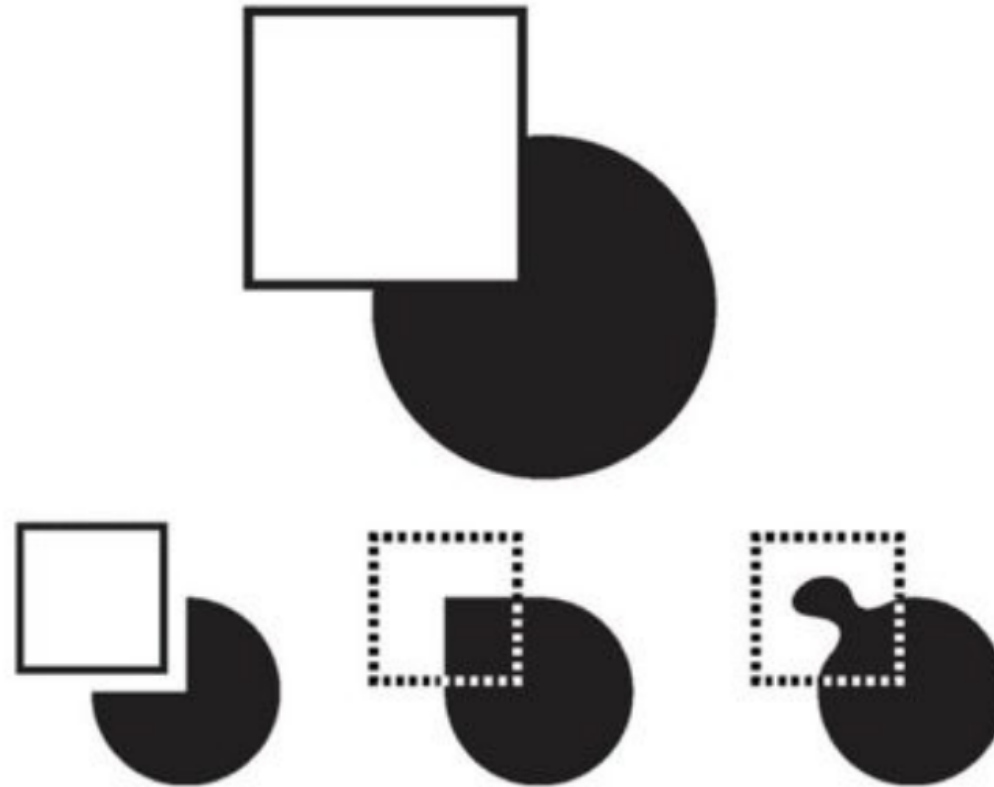
Grouping



Continuity



Continuity



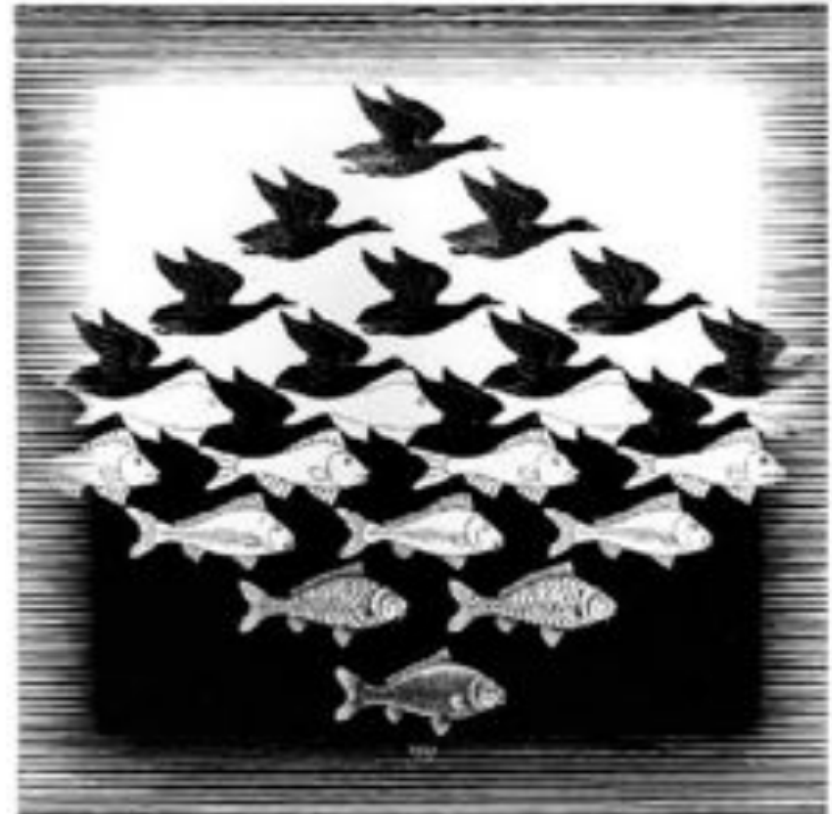
Closure



Closure



Figure / Ground



M.C. Escher: *Sky and Water I* 1938 woodcut

Figure / Ground

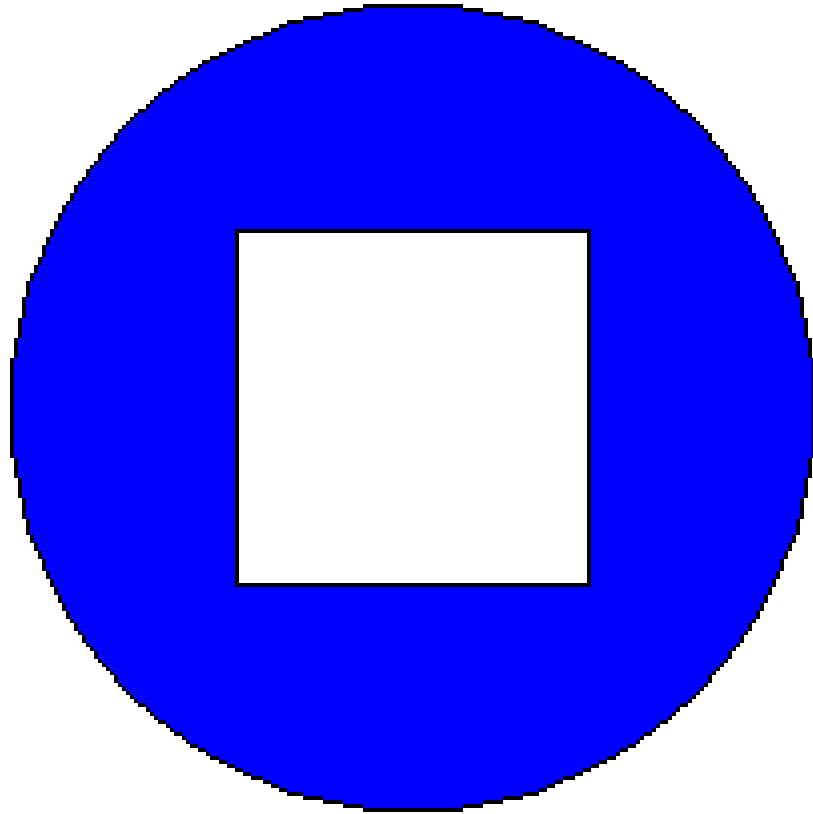


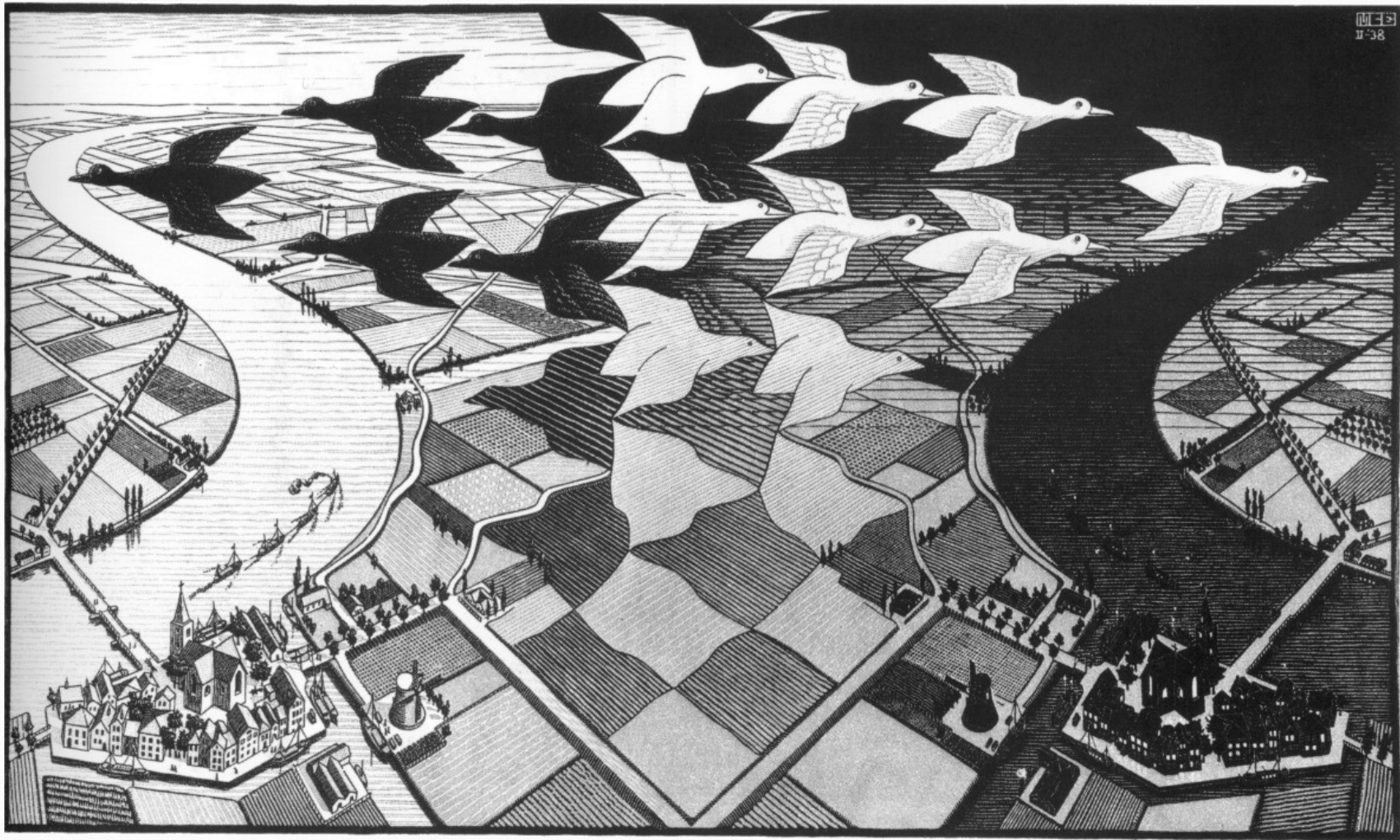
Figure / Ground



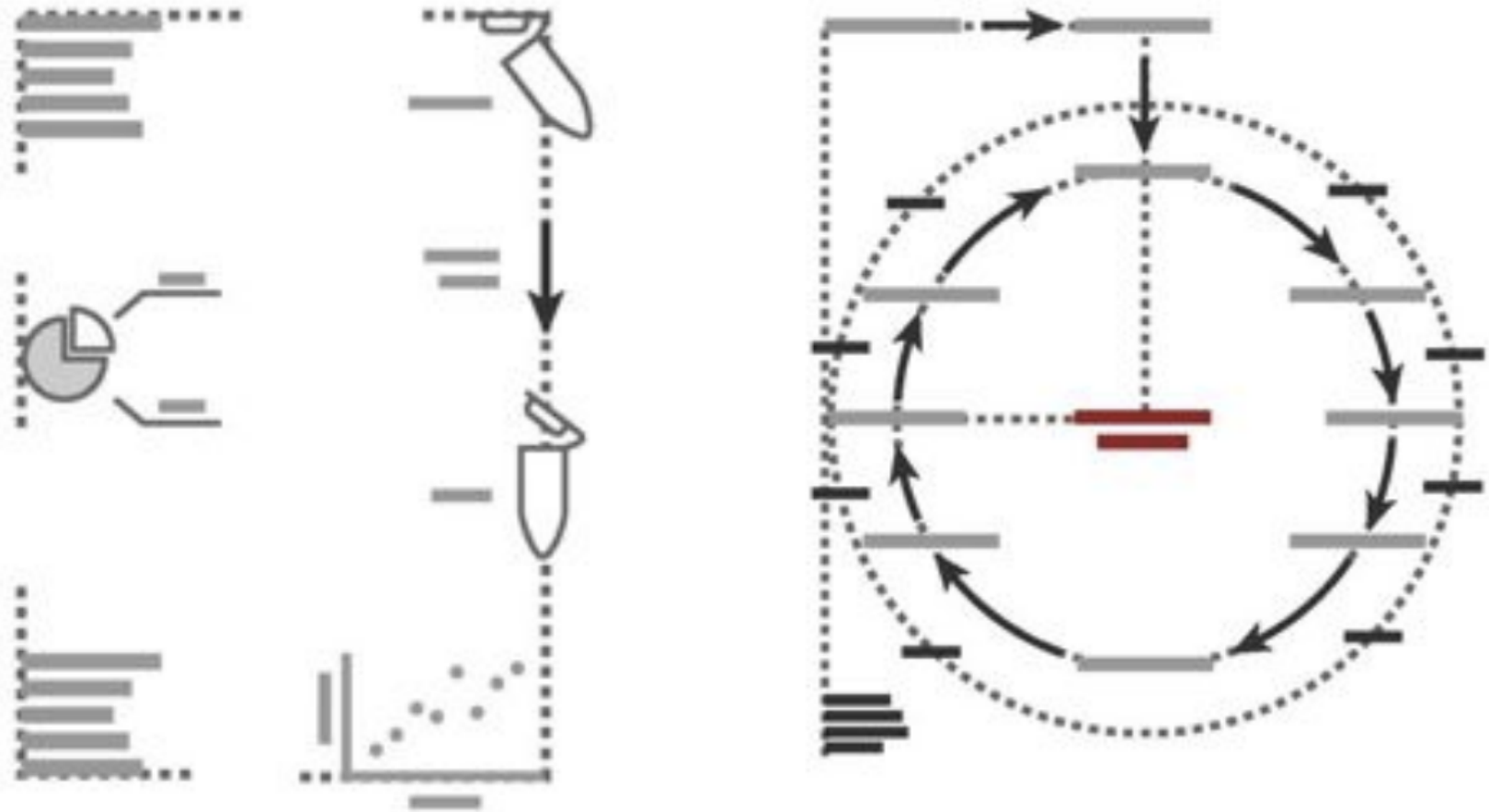
Figure / Ground



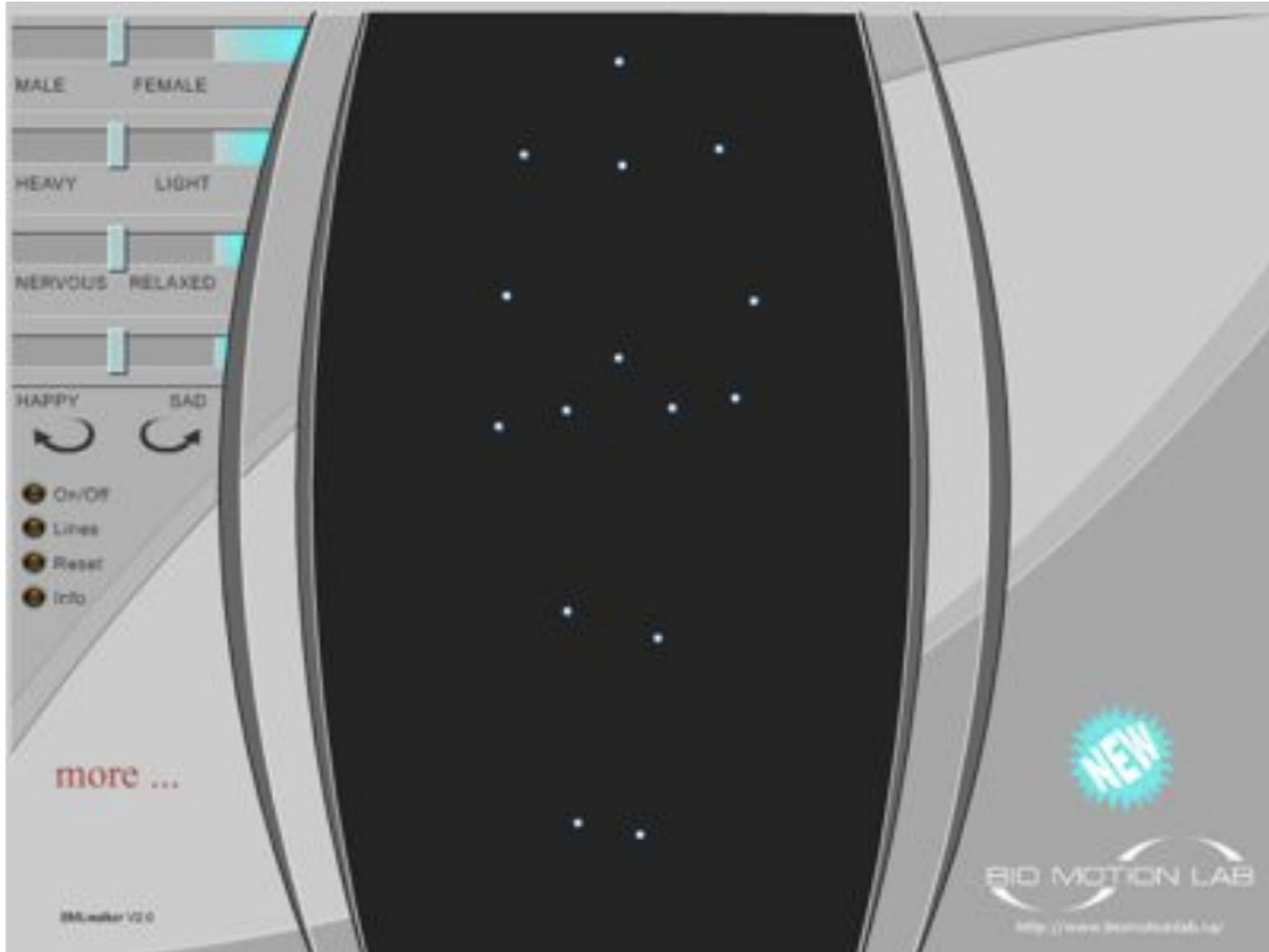
Figure / Ground



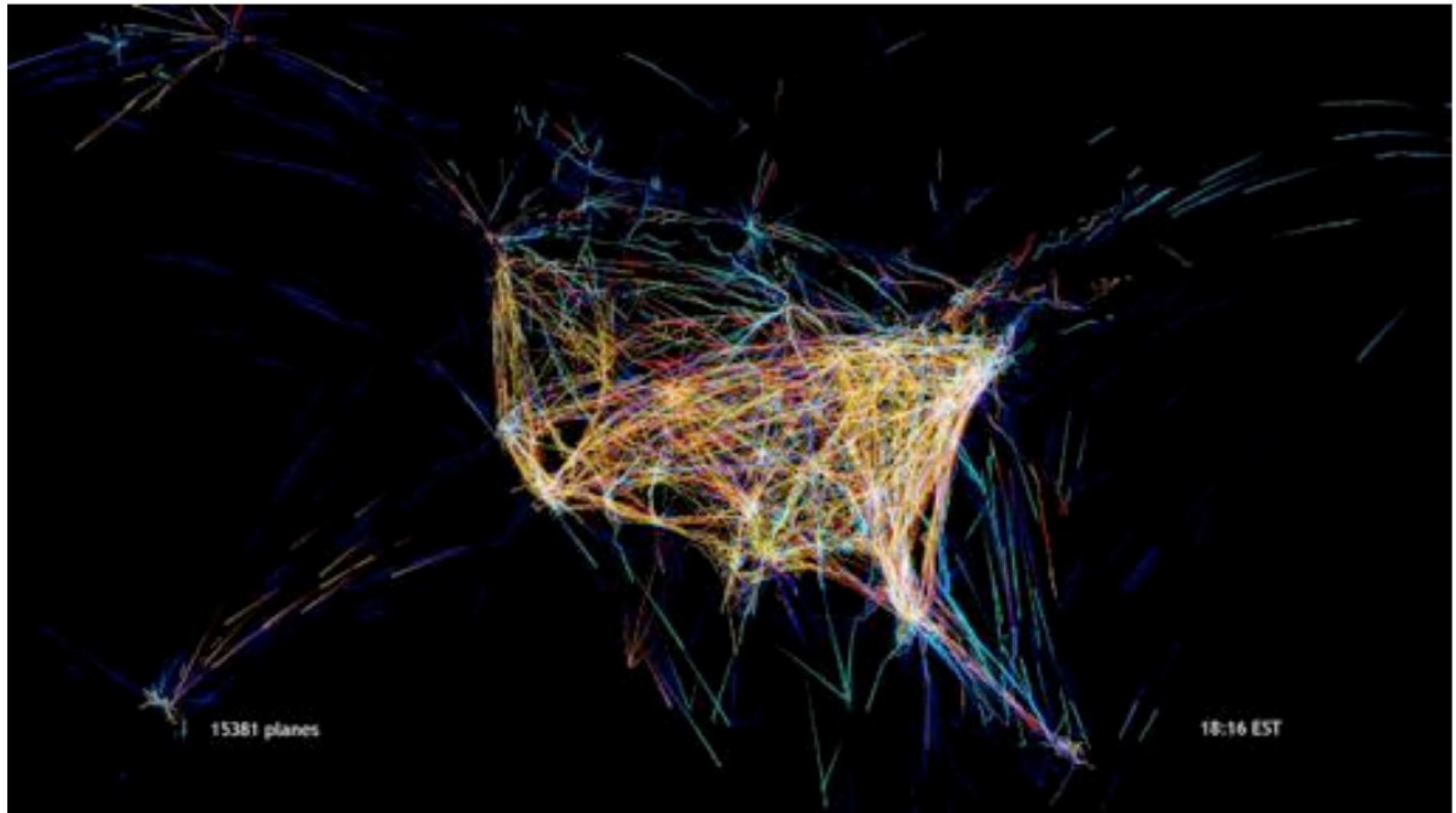
Alignment



Common Fate



Flight Patterns



Gestalt Principles

- Similarity – Things that look like each other (size, color, shape) are related
- Proximity – Things that are visually close to each other are related
- Connection – Things that are visually connected are related
- Continuity – We complete hidden objects into simple, familiar shapes
- Closure – We see incomplete shapes as complete
- Figure / Ground – Elements are perceived as either figures or background
- Common Fate — Elements with the same moving direction are perceived as a unit