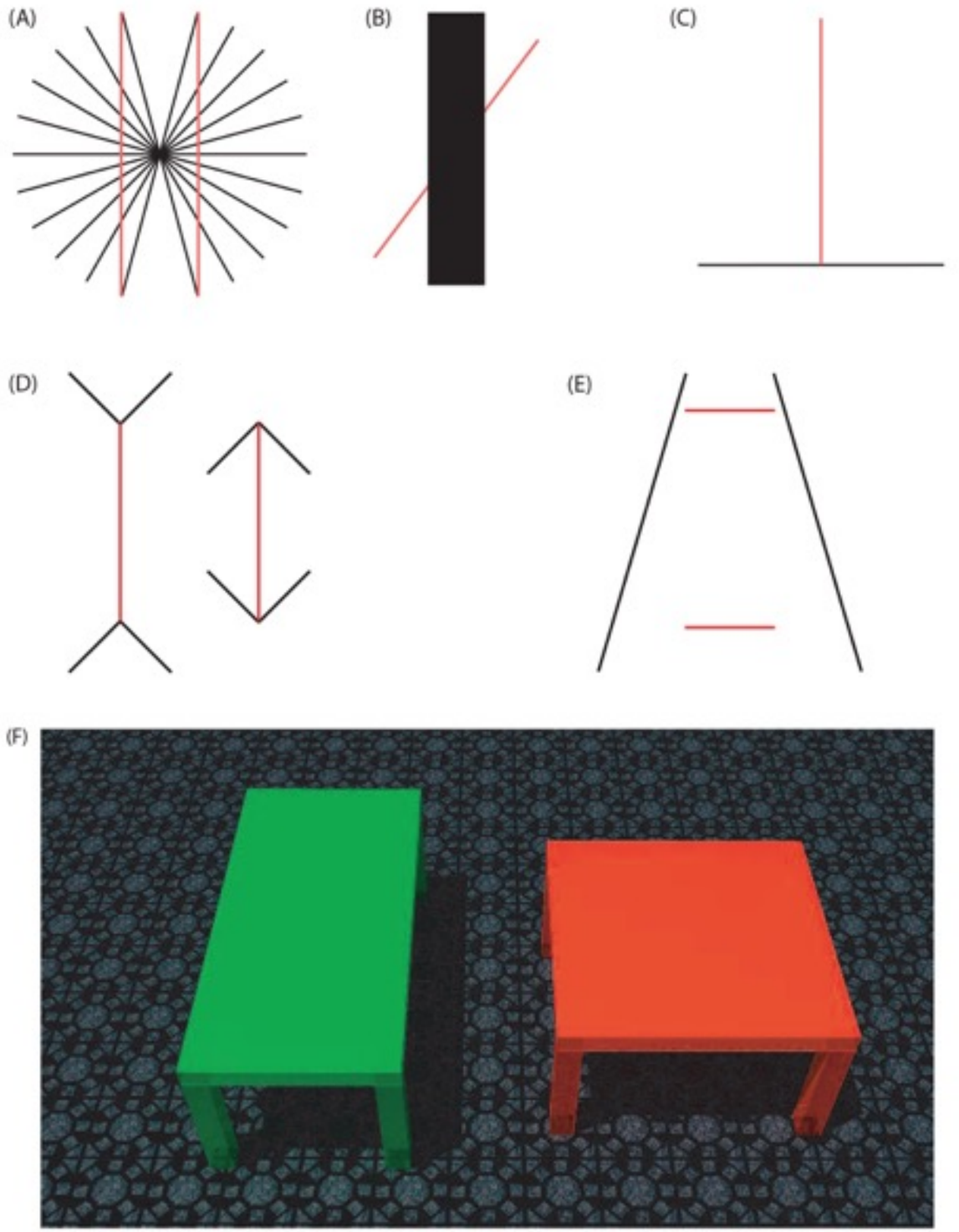
Module # 3— Seeing Space

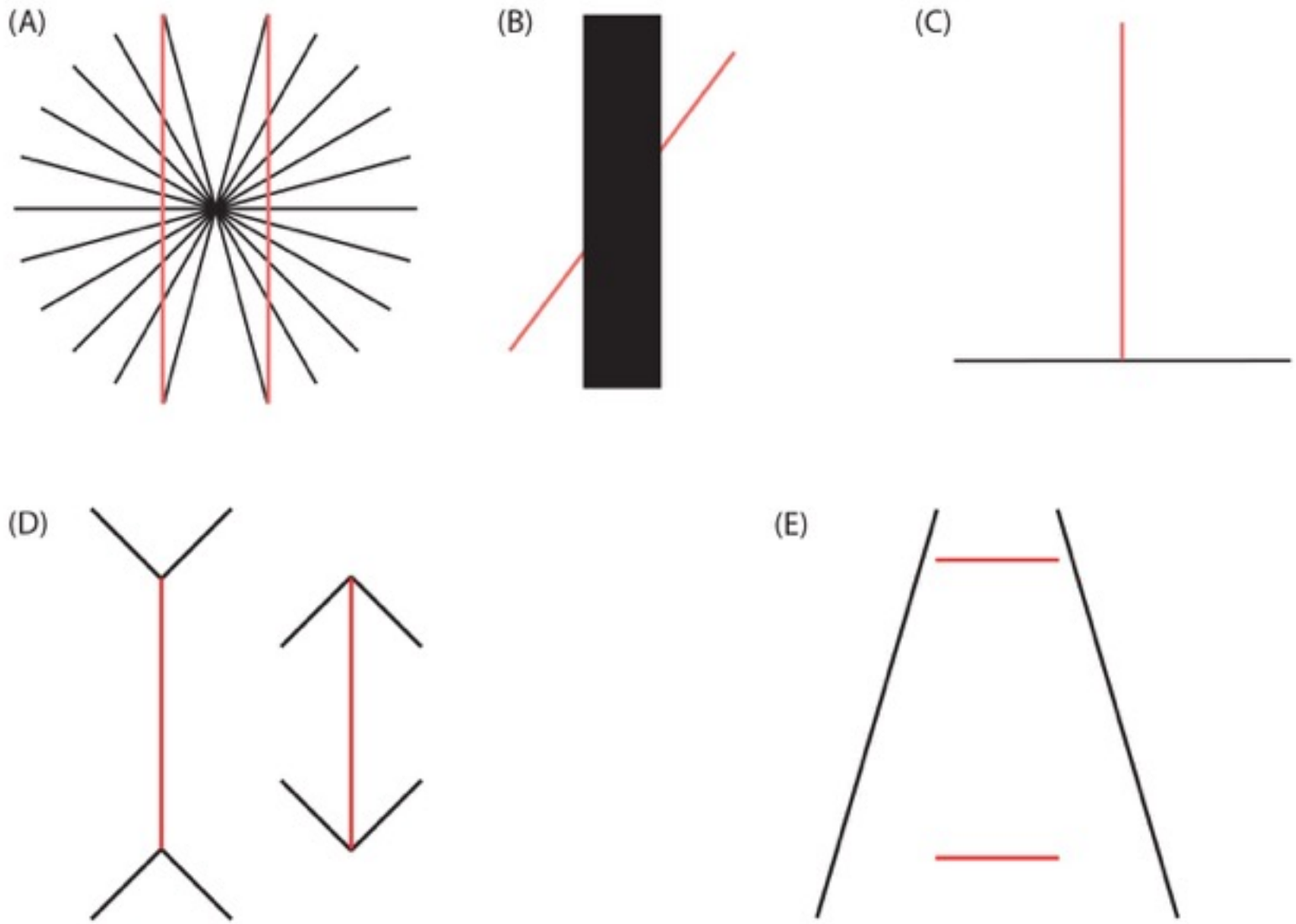
Visual Perception and the Brain

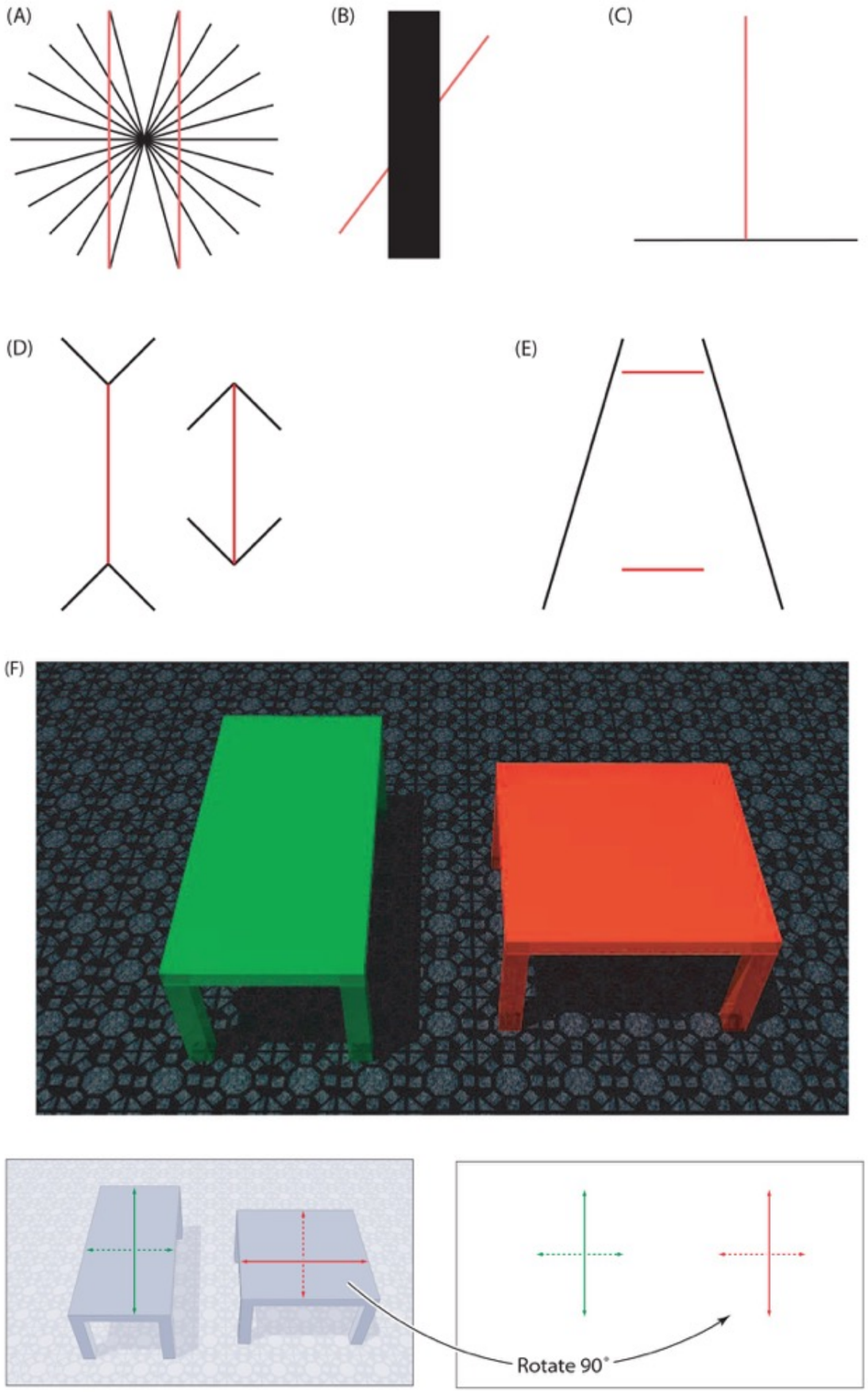
DUKE INSTITUTE *for* BRAIN SCIENCES

Topic 1. Seeing Geometry

Lesson 1. Geometrical “Illusions”







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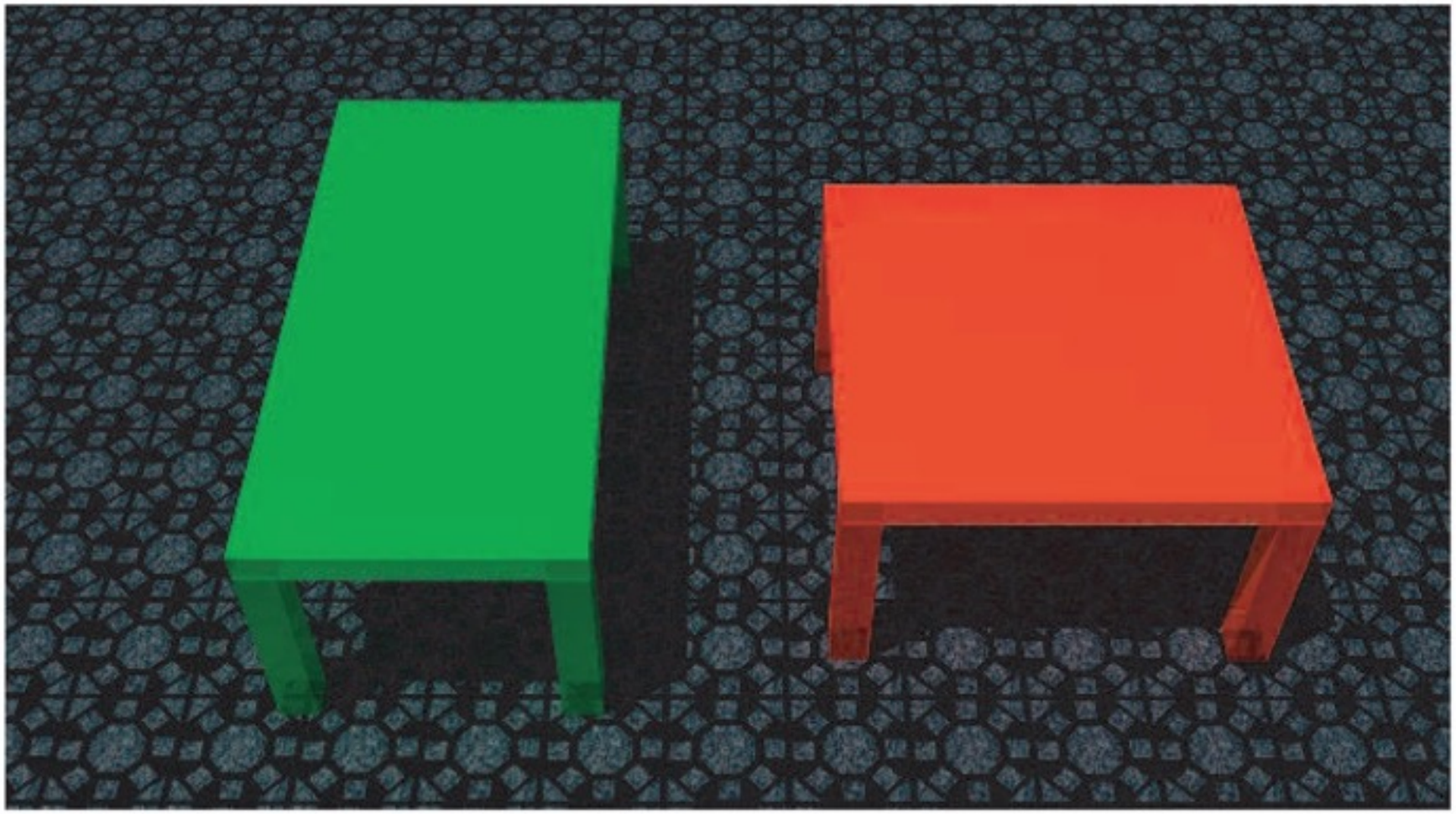
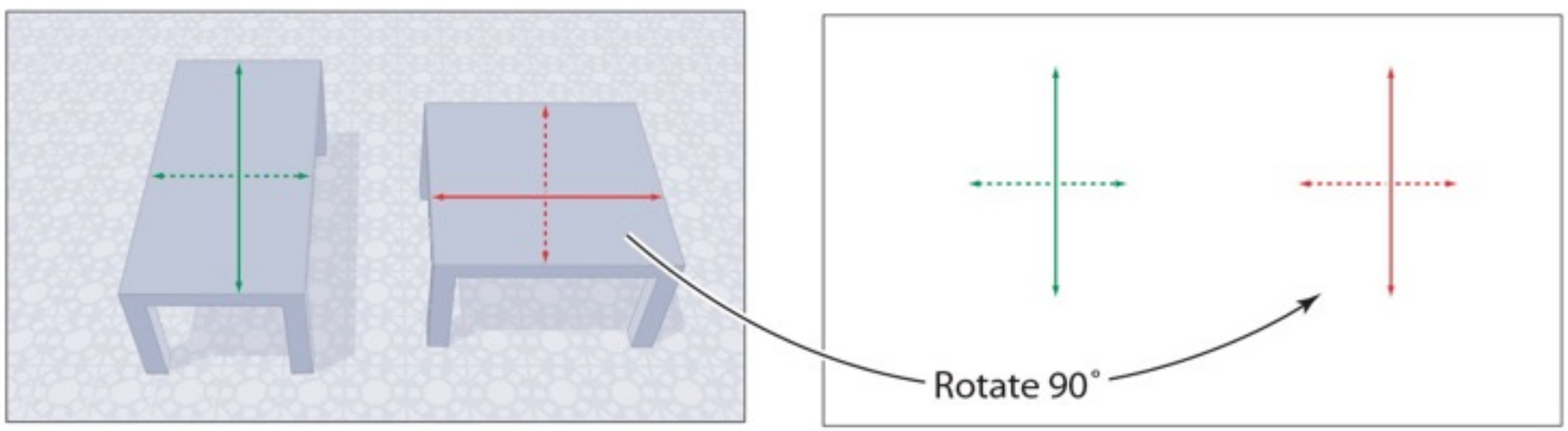
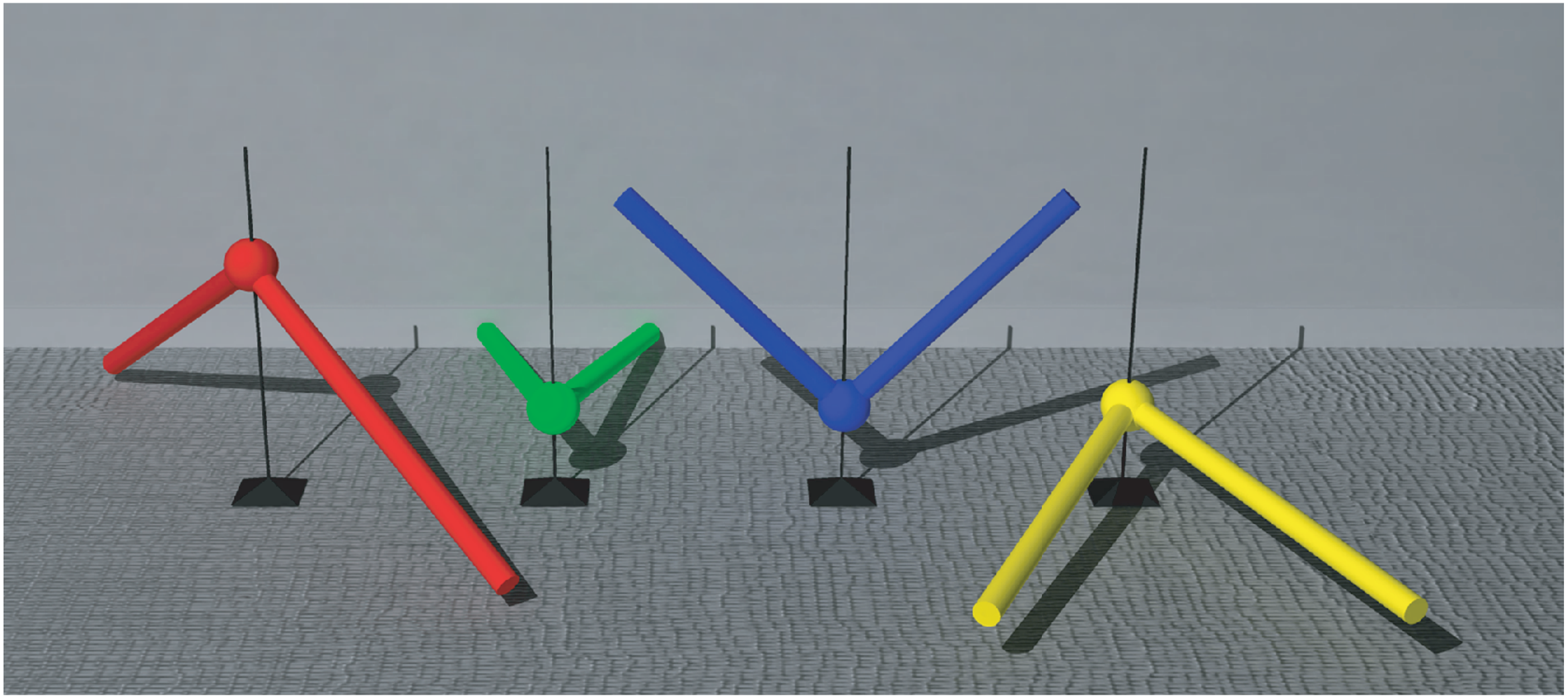
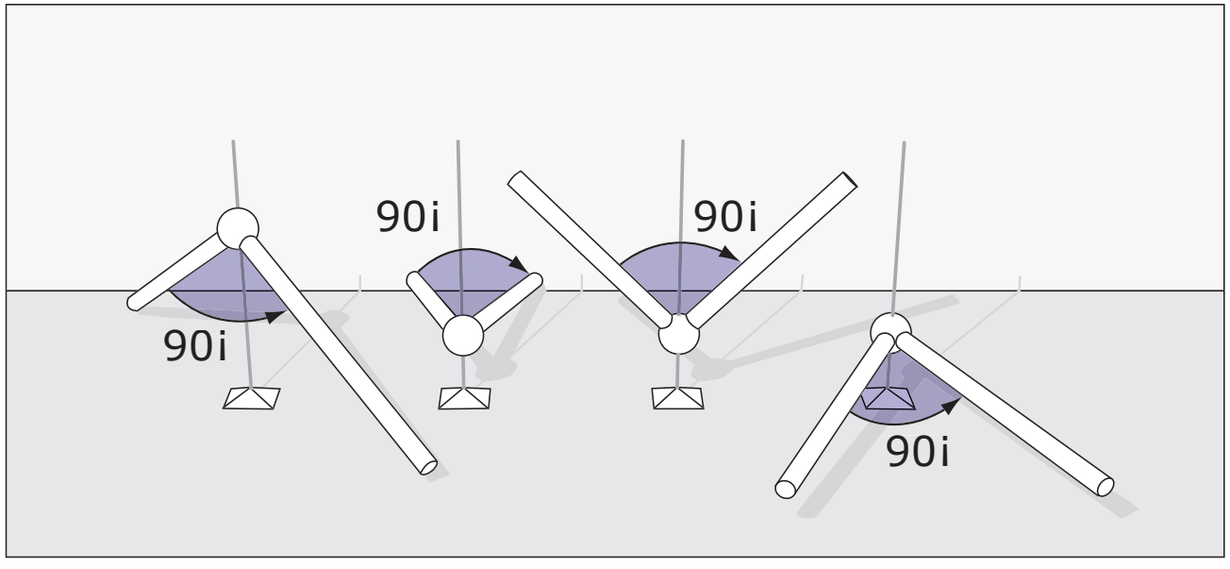
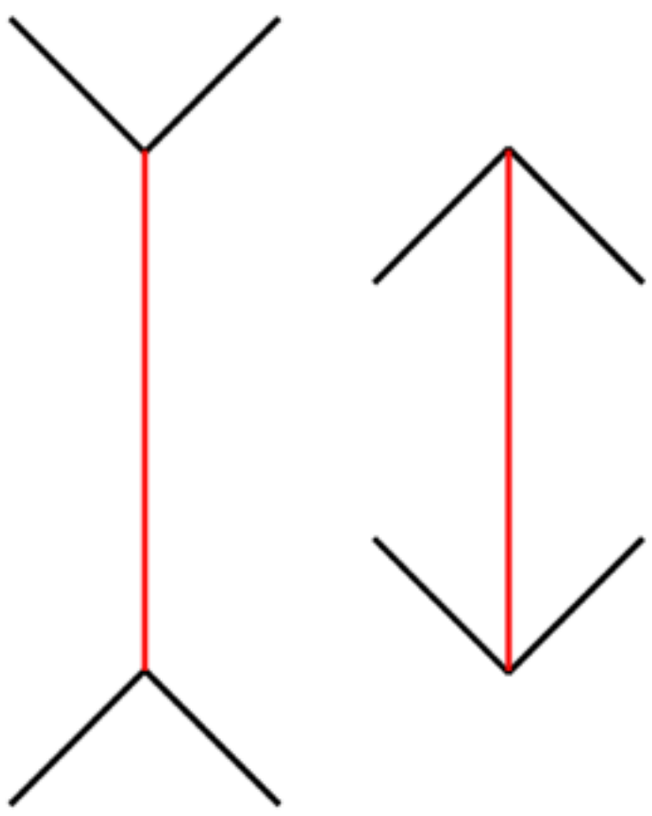




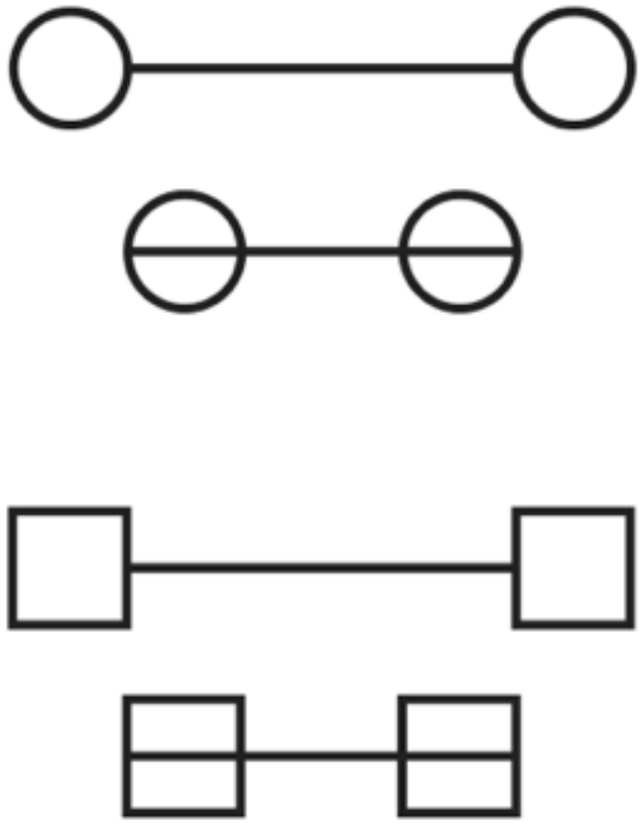




As in the cases of lightness and color, intuitions quickly fail in trying to explain these phenomena

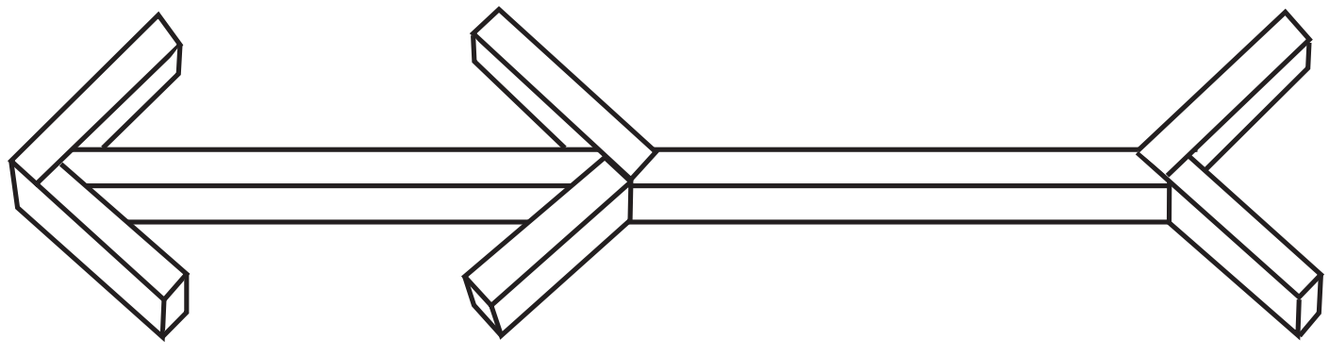


The Müeller-Lyer effect



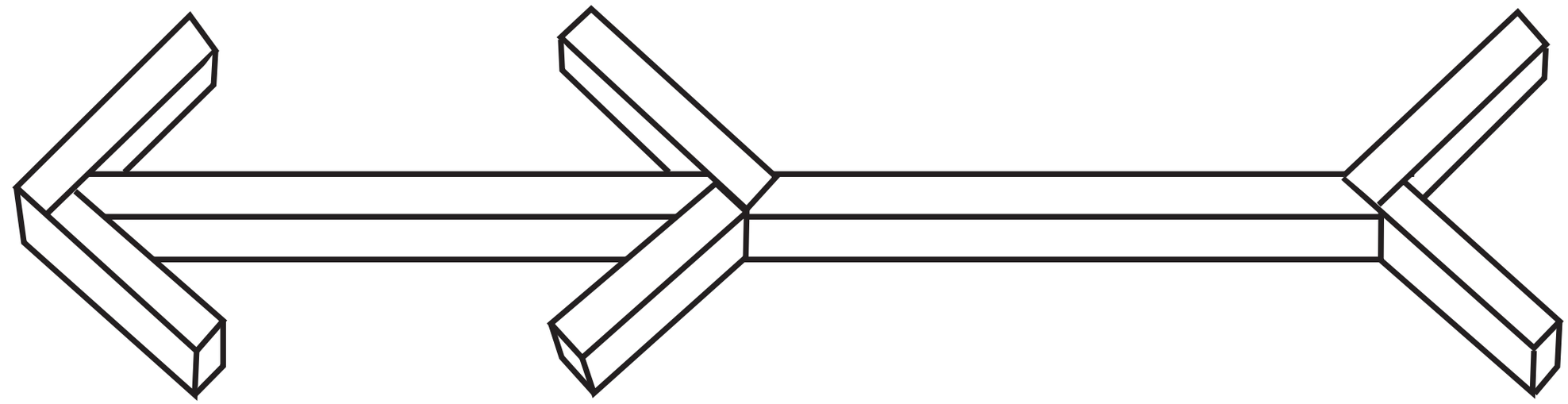
These effects are apparent in real-world scenes

A



B

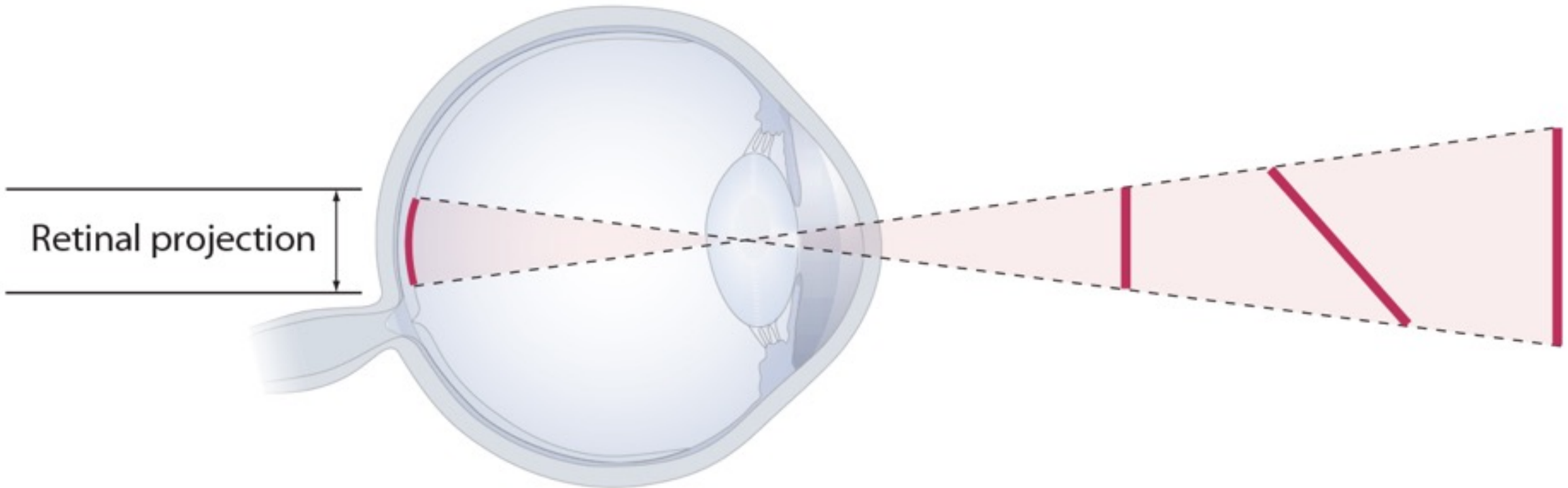
A



B

Lesson 2. The Inverse Problem in Geometry

Remember the Basic Problem in Perceiving Geometry

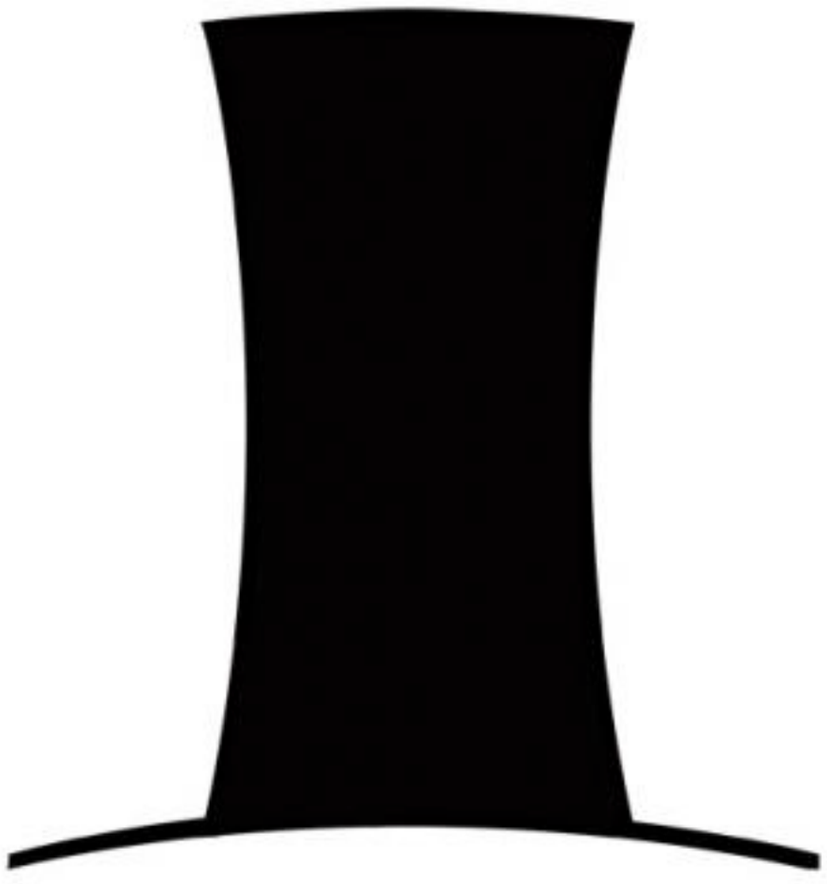


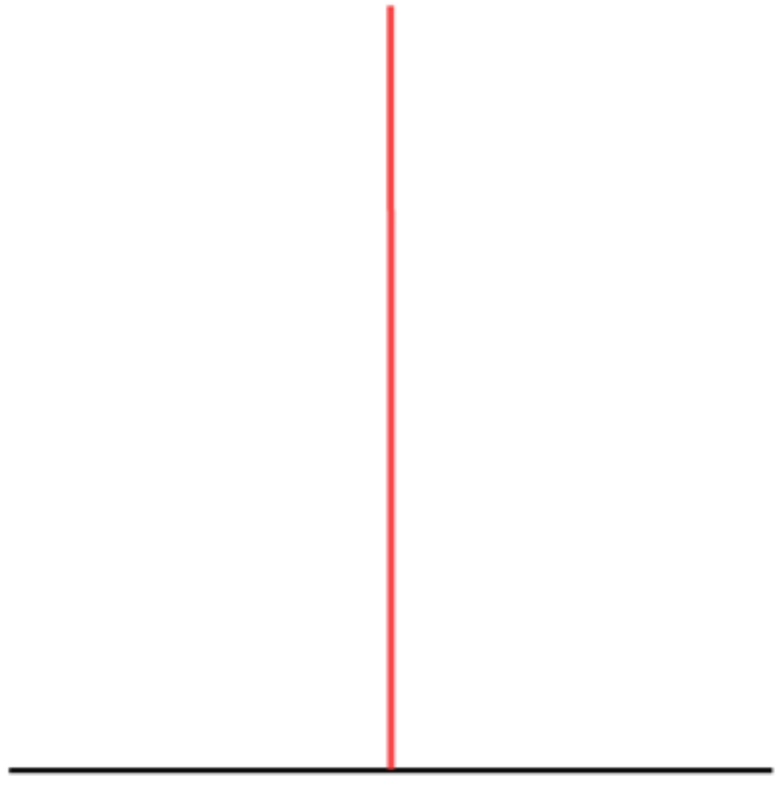
Remember the Basic Problem in Perceiving Geometry

- The significance of image features for behavior in the real world, including geometrical features, is inherently uncertain
- Implication: real world geometry is unknowable by any direct, logical operation on retinal images
- So how is it that we behave appropriately in responding to the geometry of the world?

Lesson 3. Seeing the Length of Lines

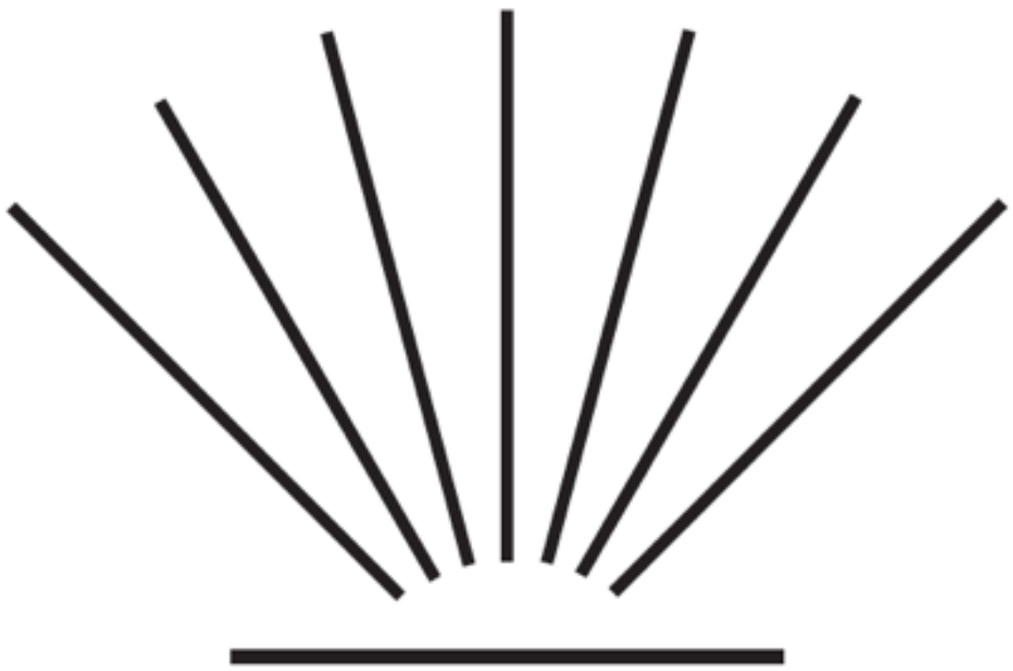
The “Lincoln Hat Illusion”



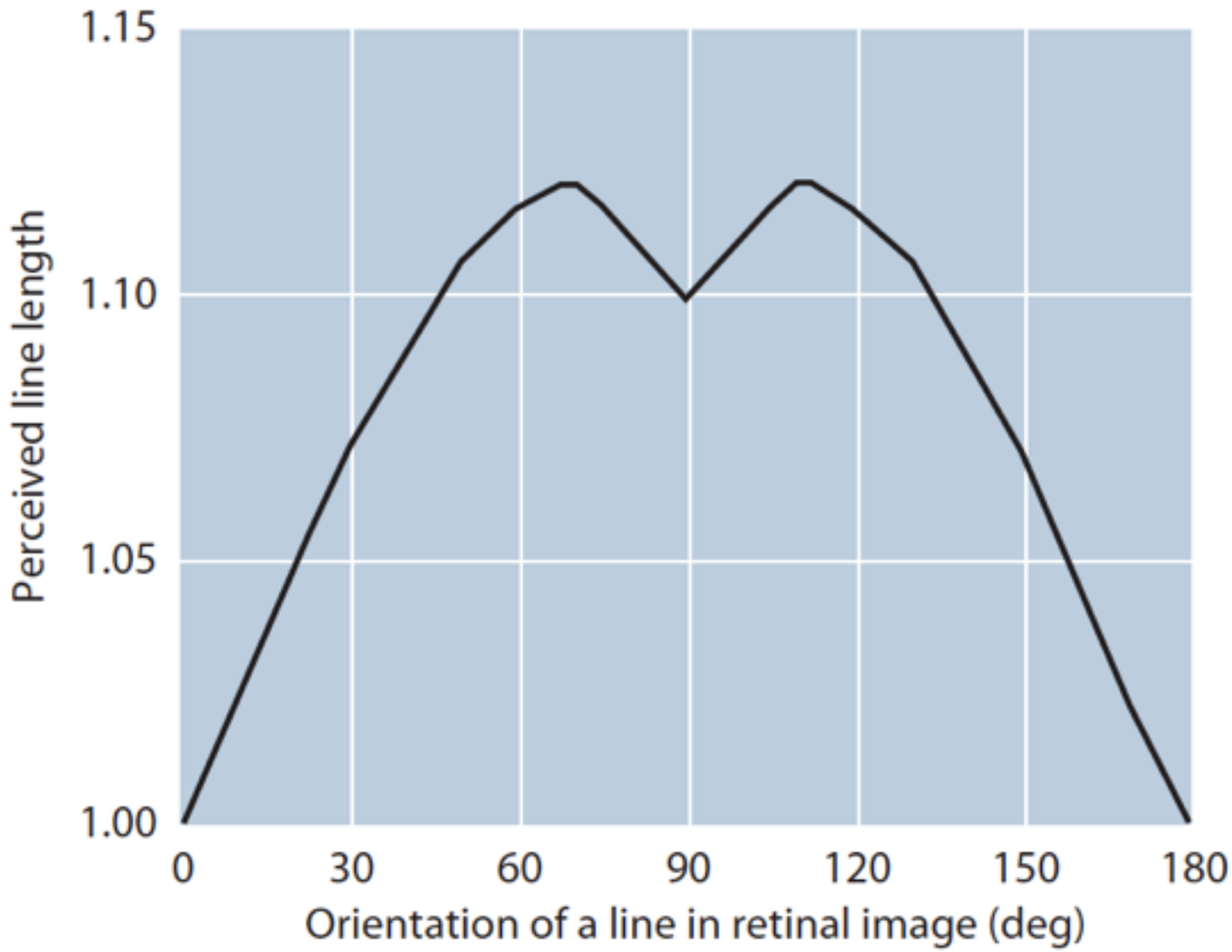


The perception of line length as a function of orientation

(A)

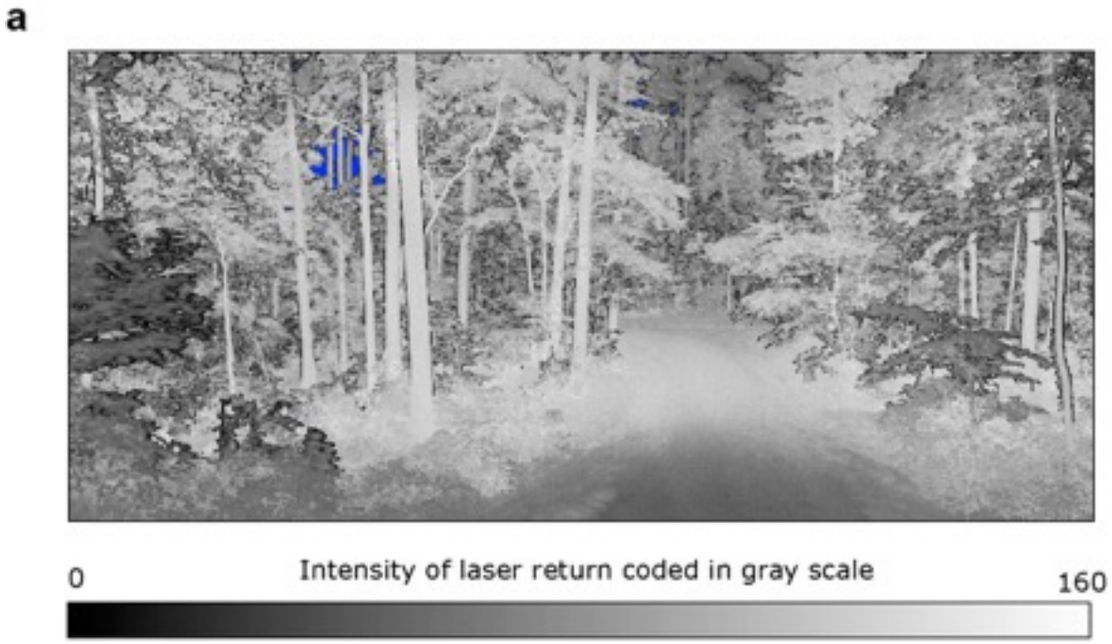


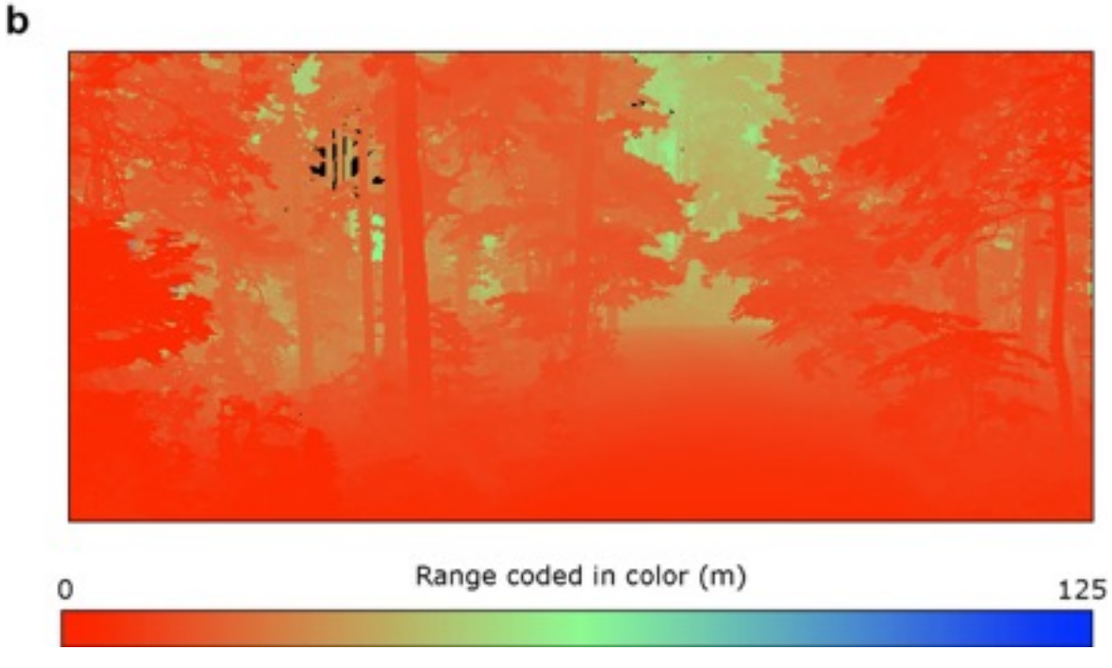
(B)



Lesson 4. An Empirical Explanation

Gathering the Relevant Human Experience

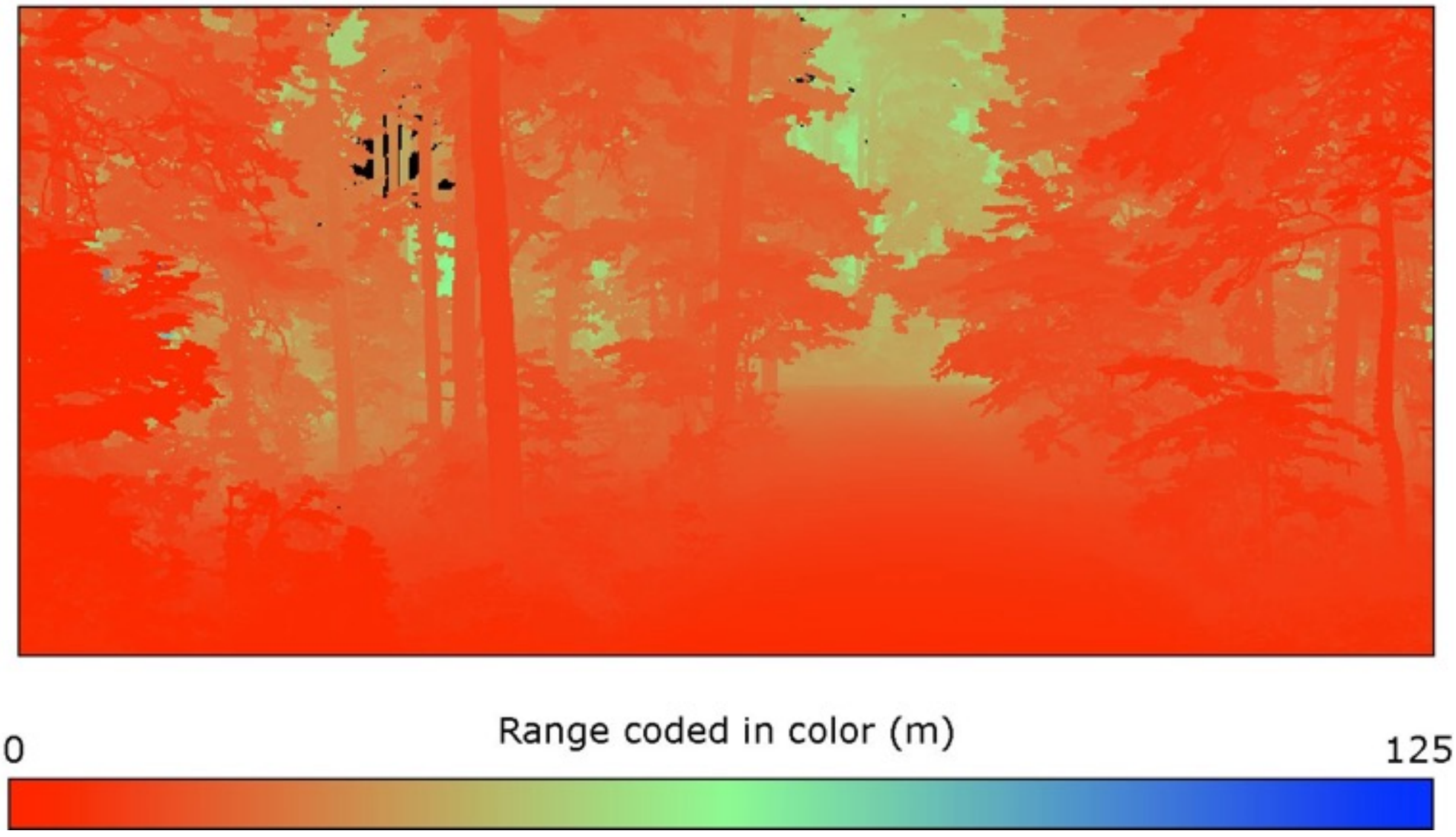




a

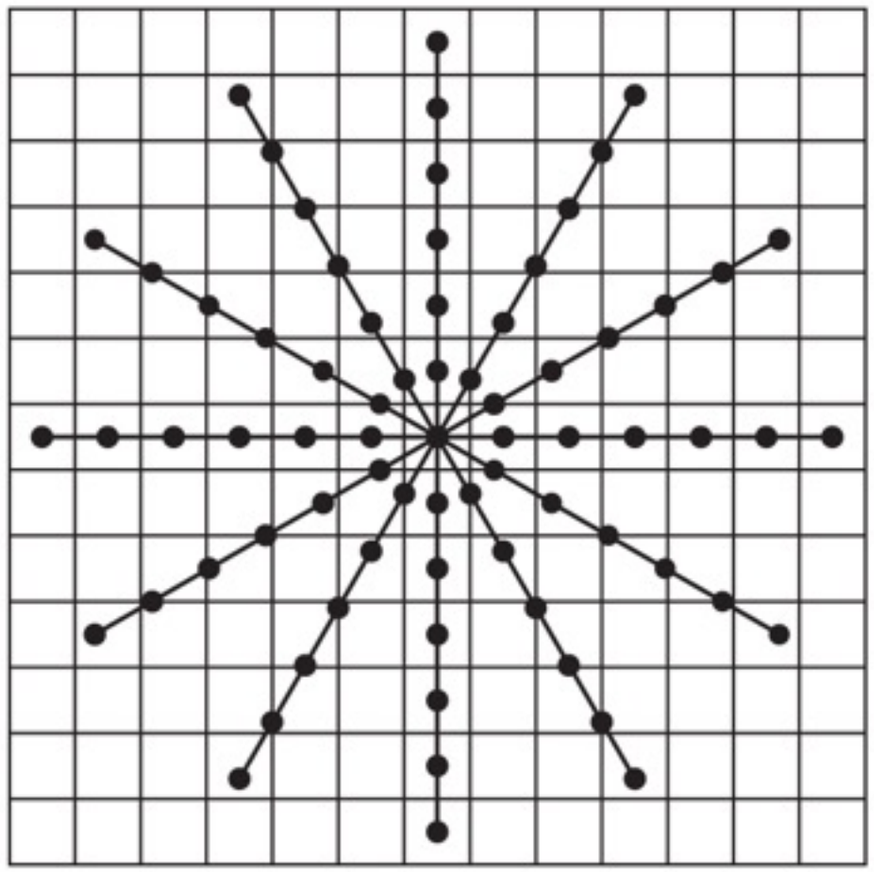
0 Intensity of laser return coded in gray scale 160

b



Analyzing human experience with oriented lines

(A)



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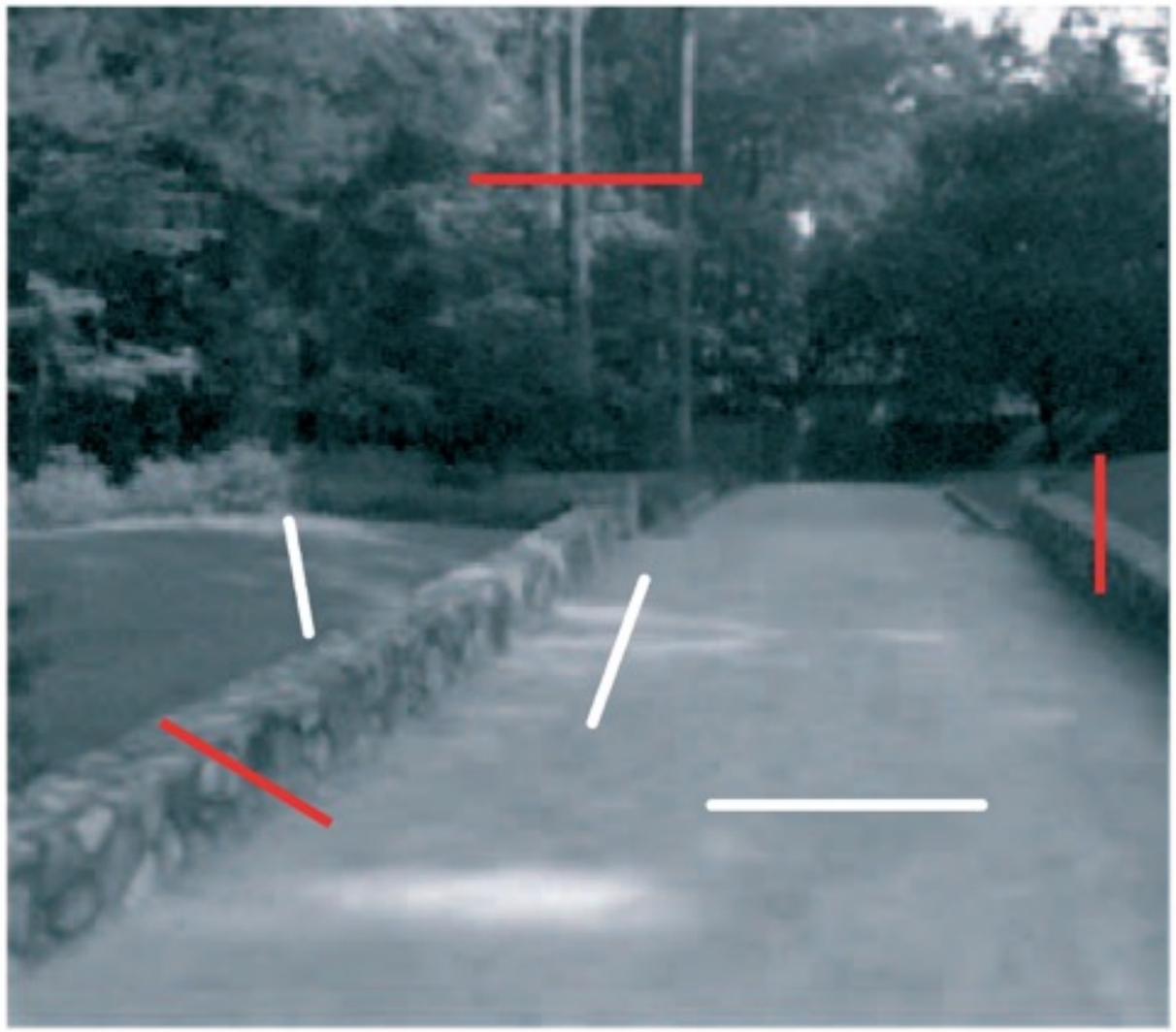
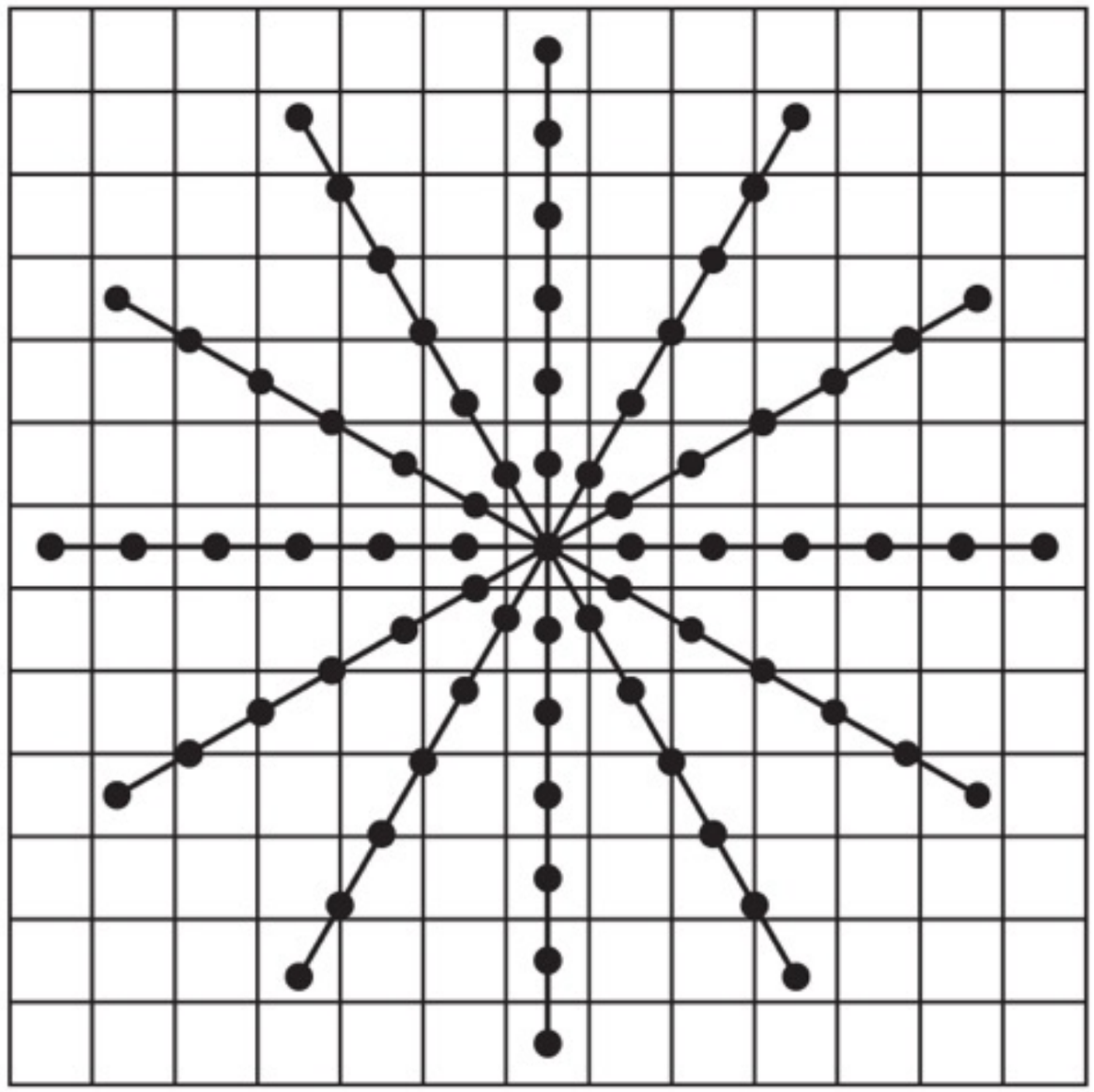


(A)



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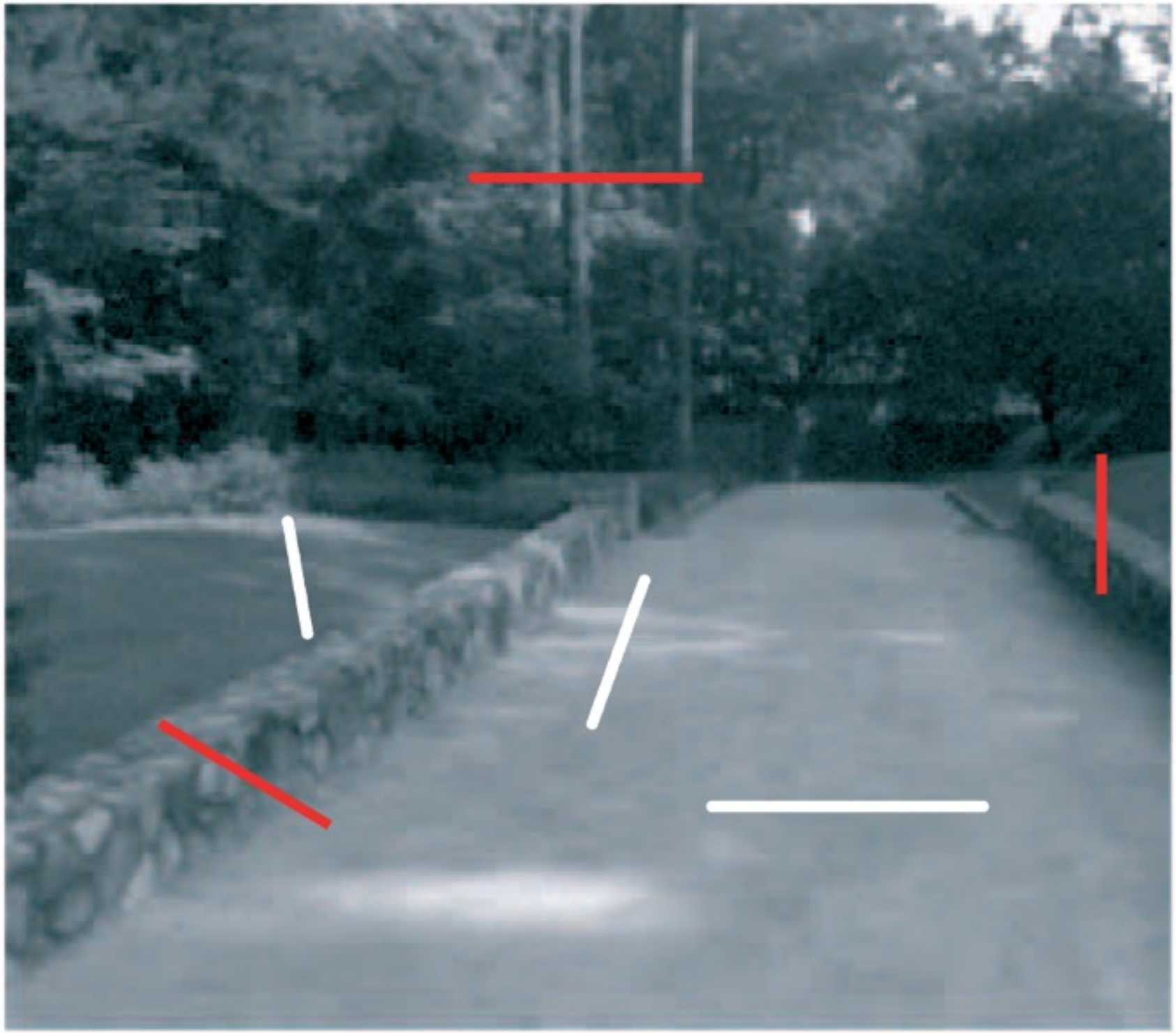
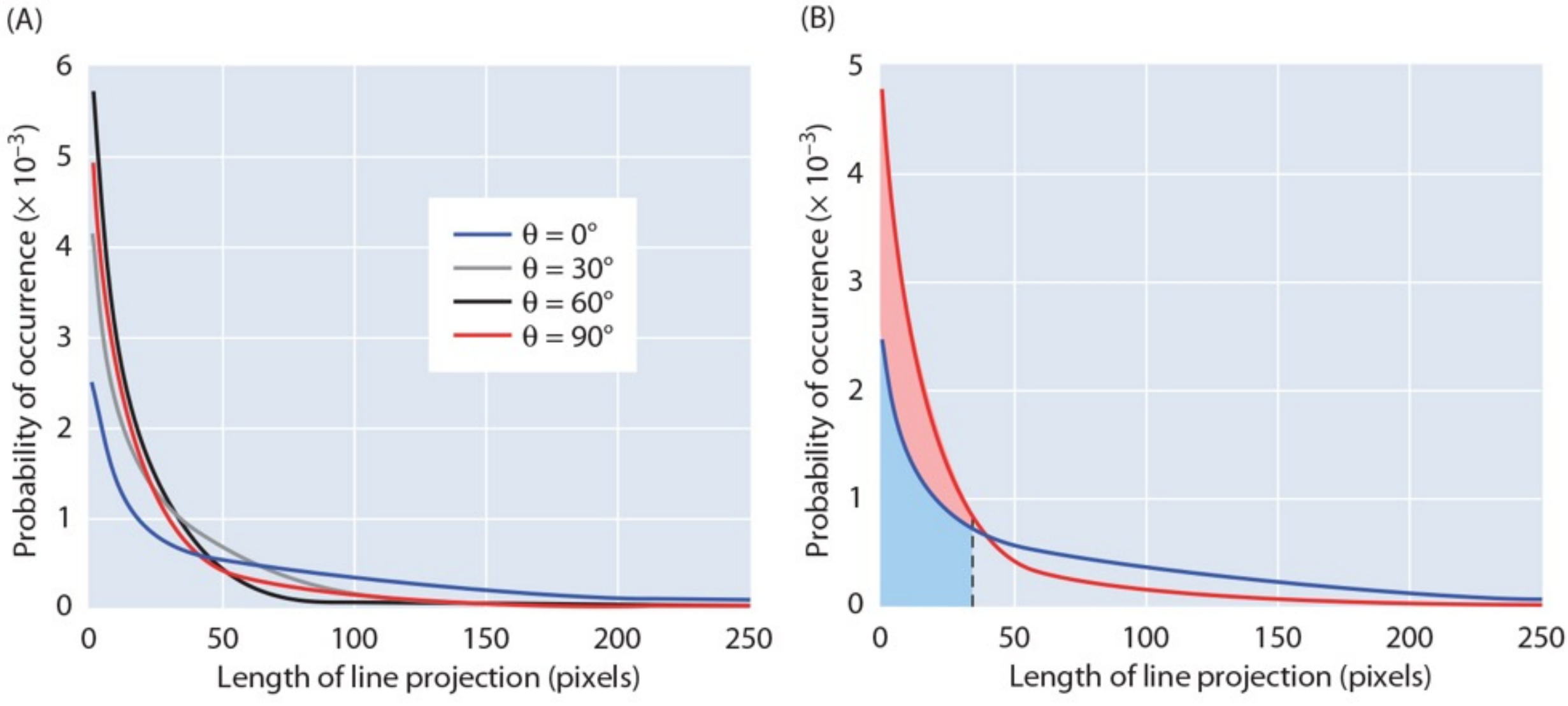
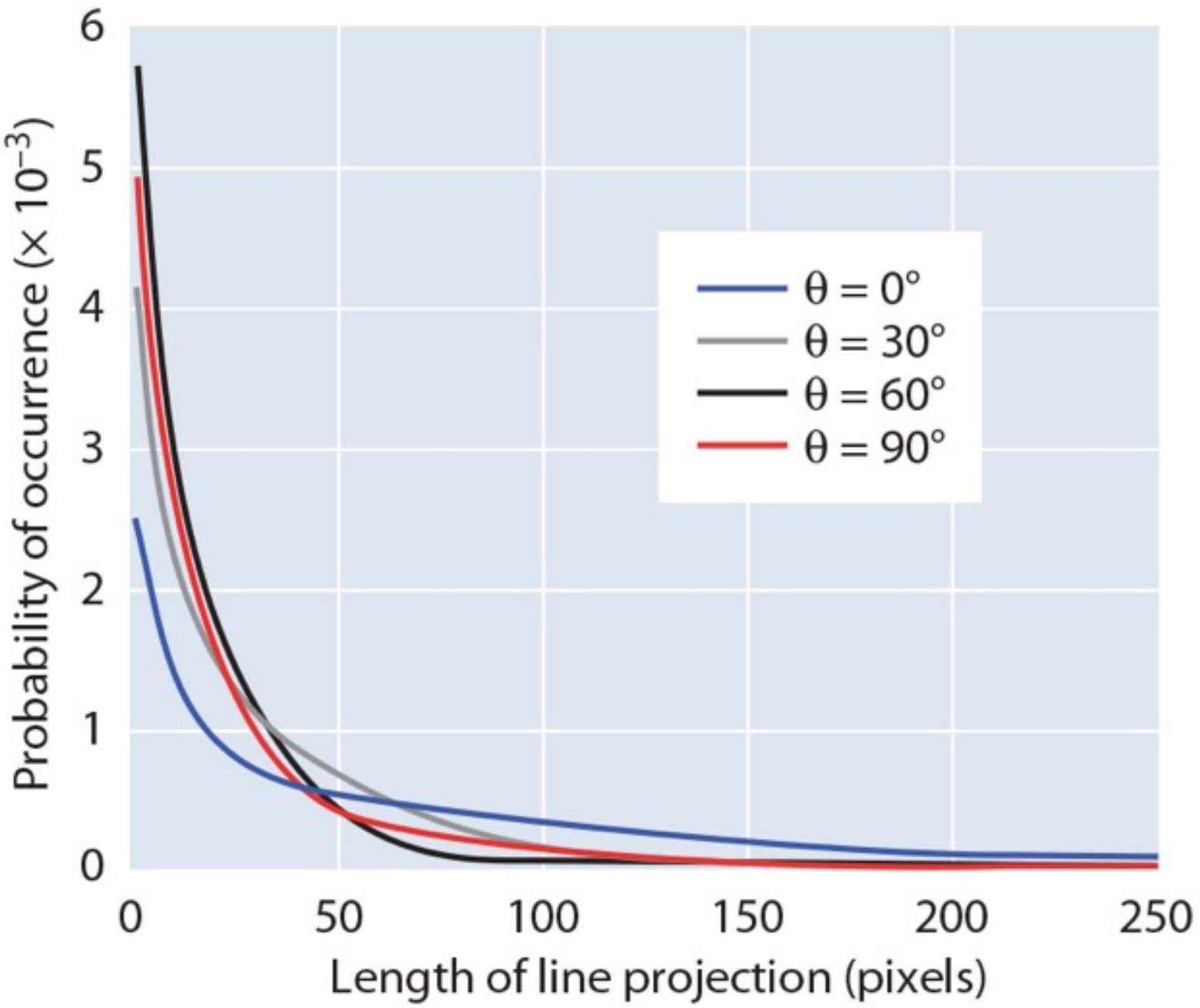


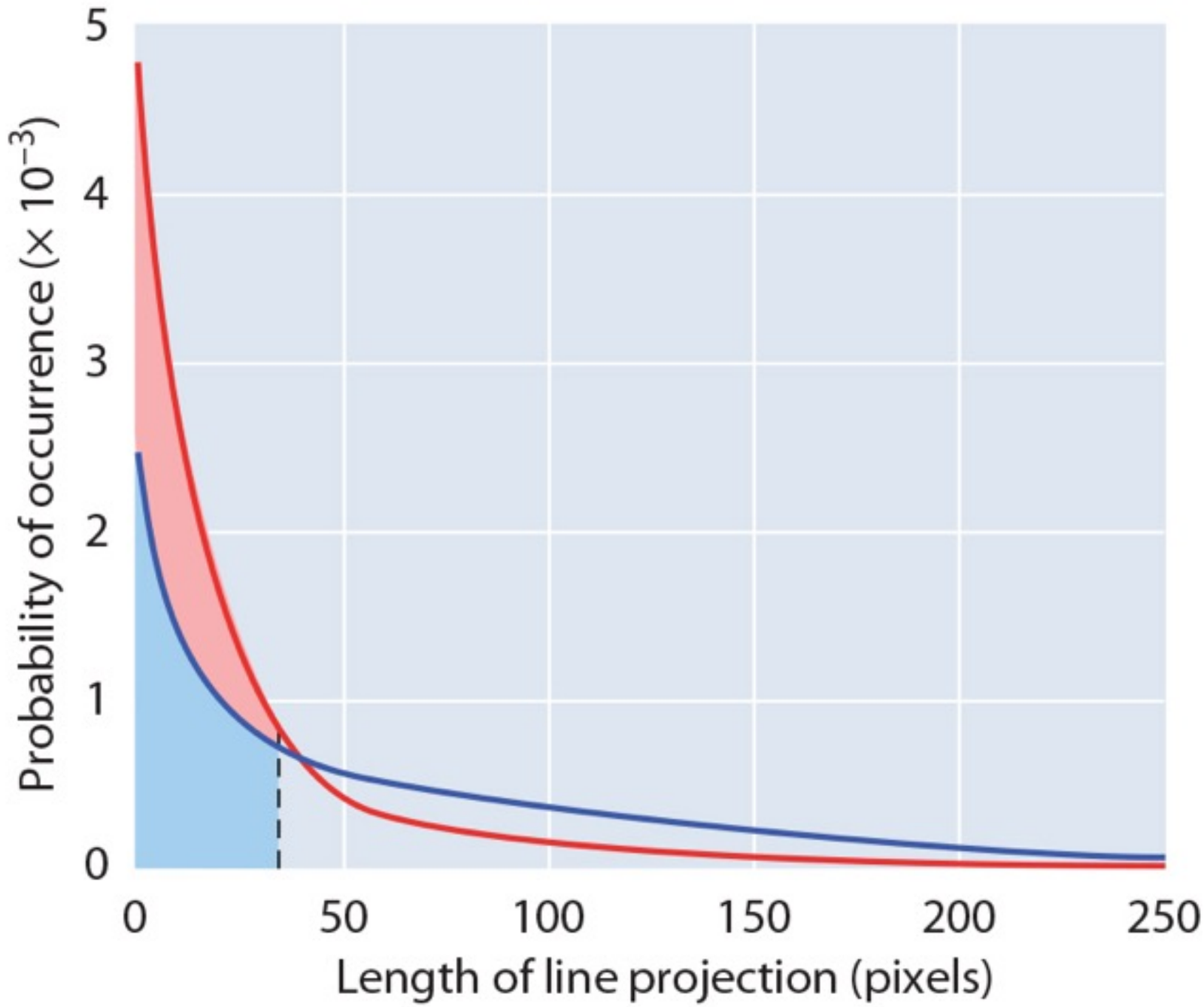
Results of the analysis



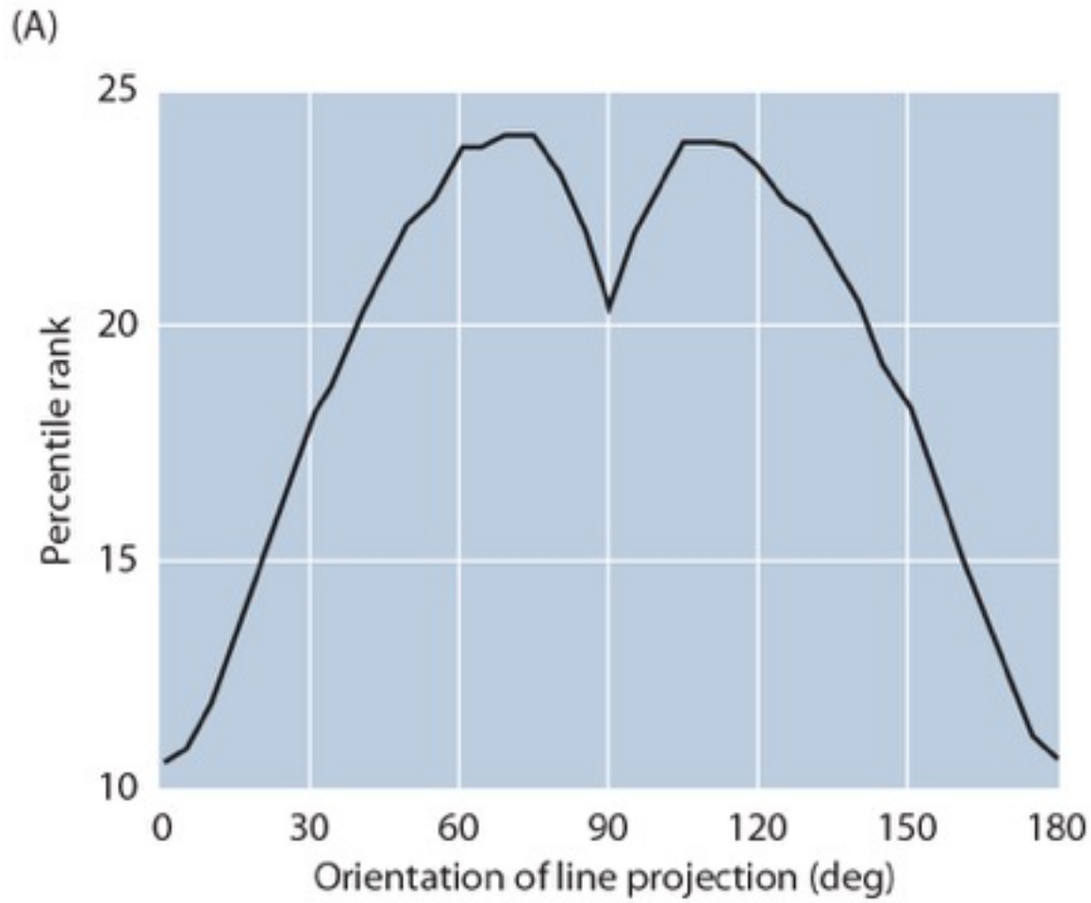
Results of the Analysis



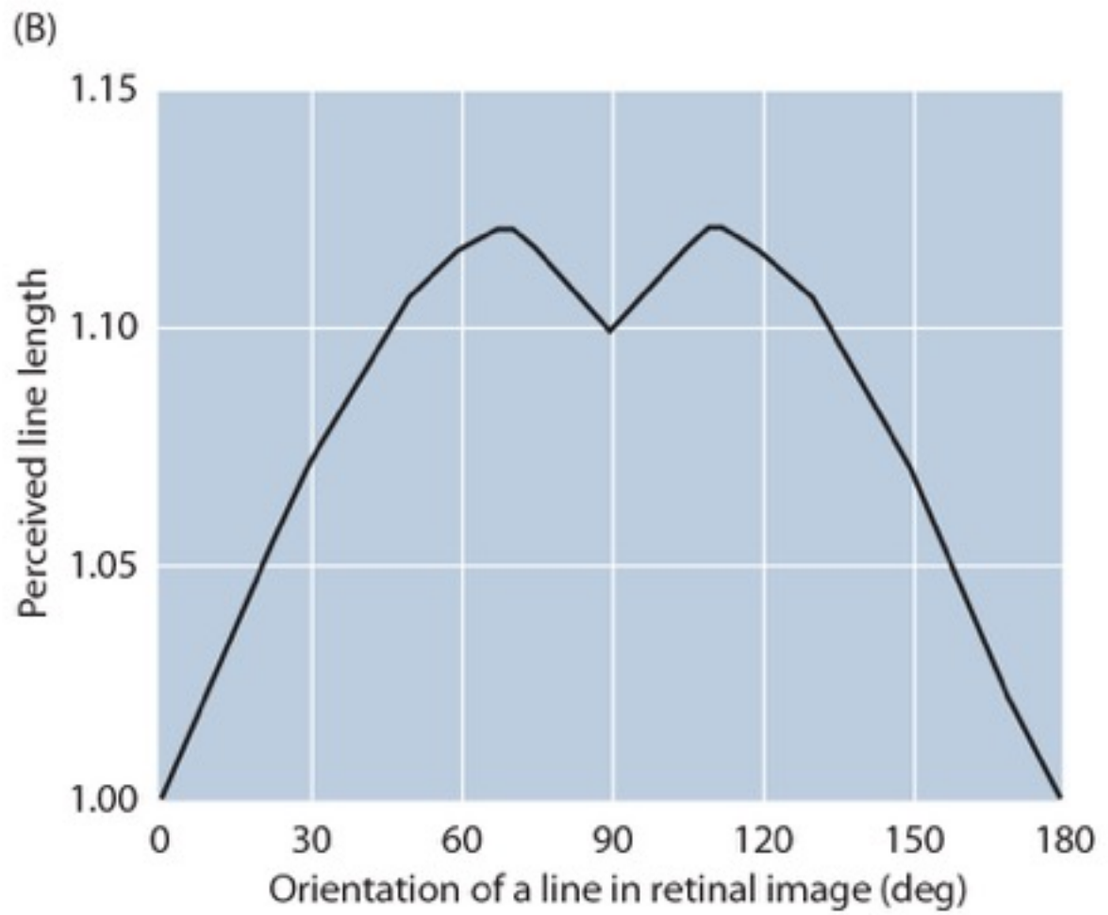
Results of the Analysis



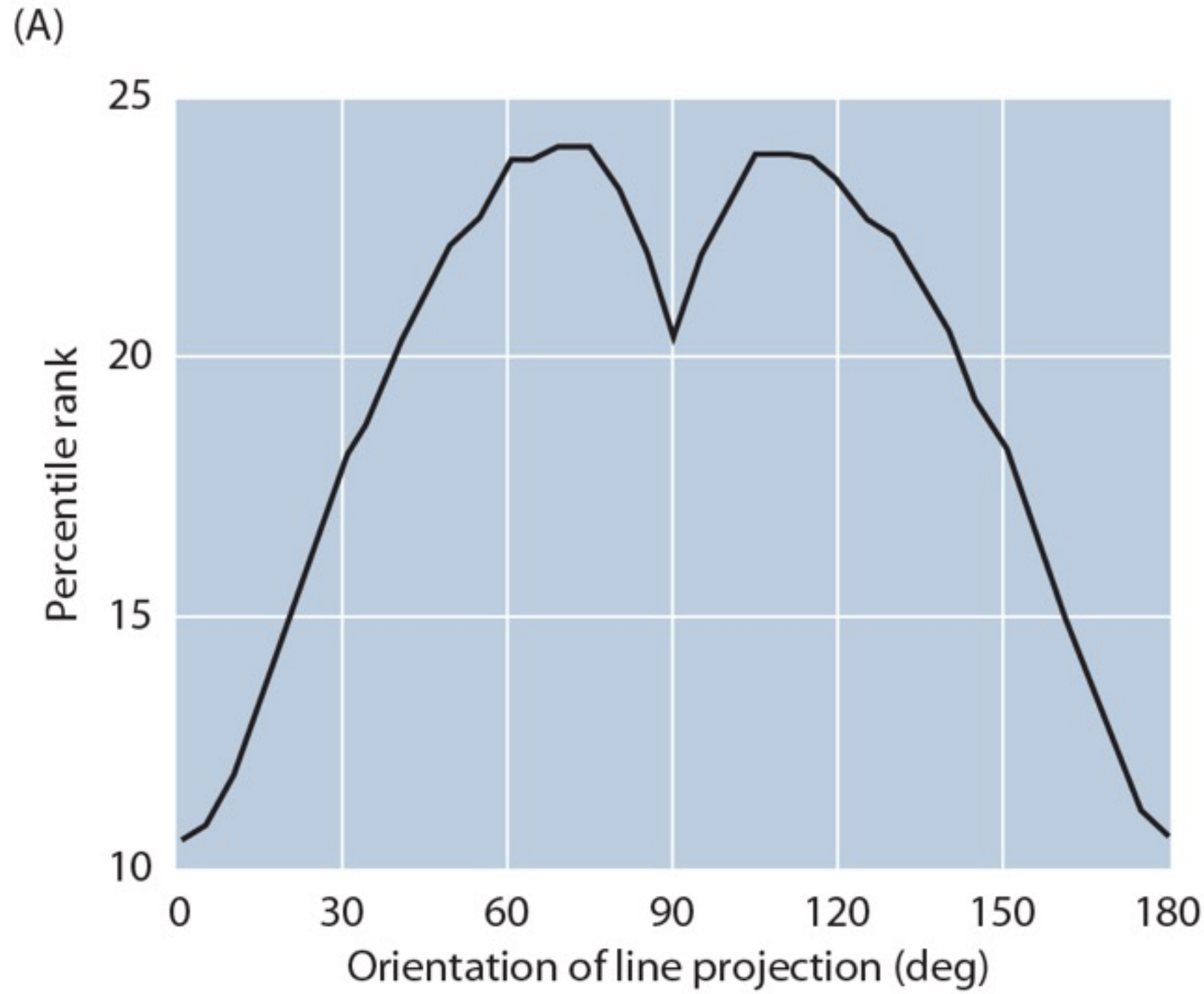
Prediction from frequency of experience



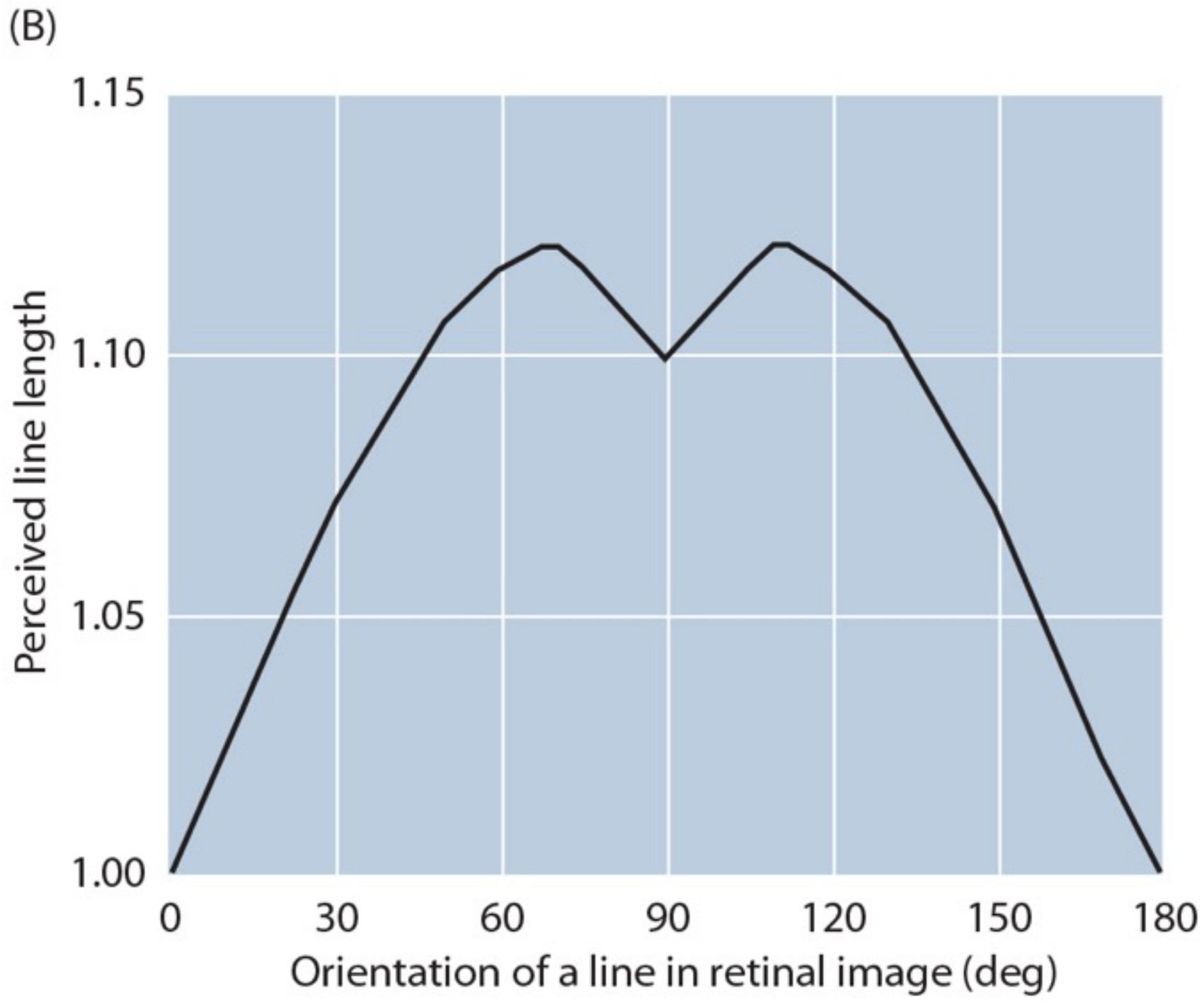
Perceptual function



Prediction from frequency of experience

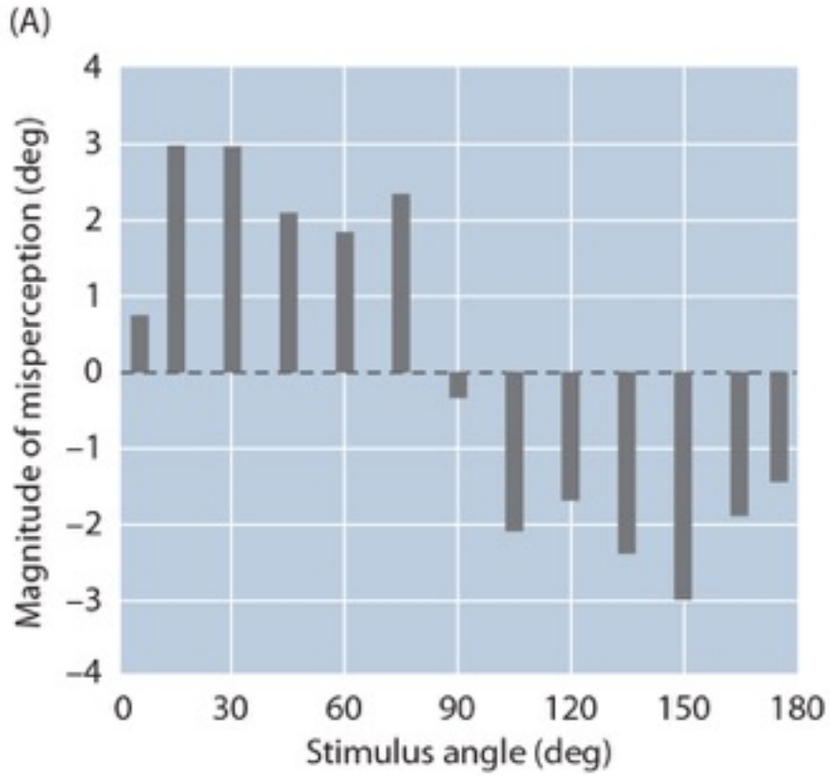


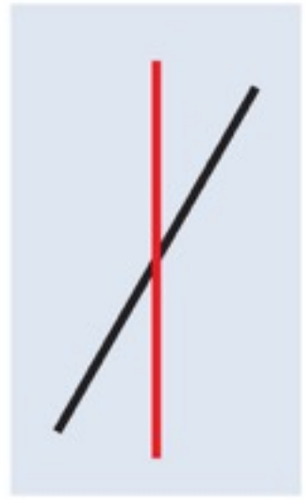
Perceptual function

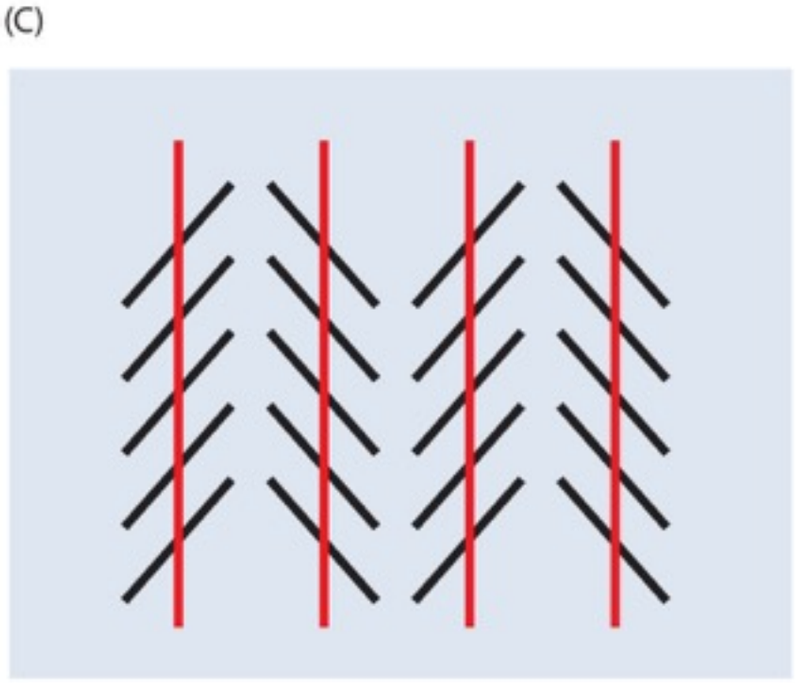


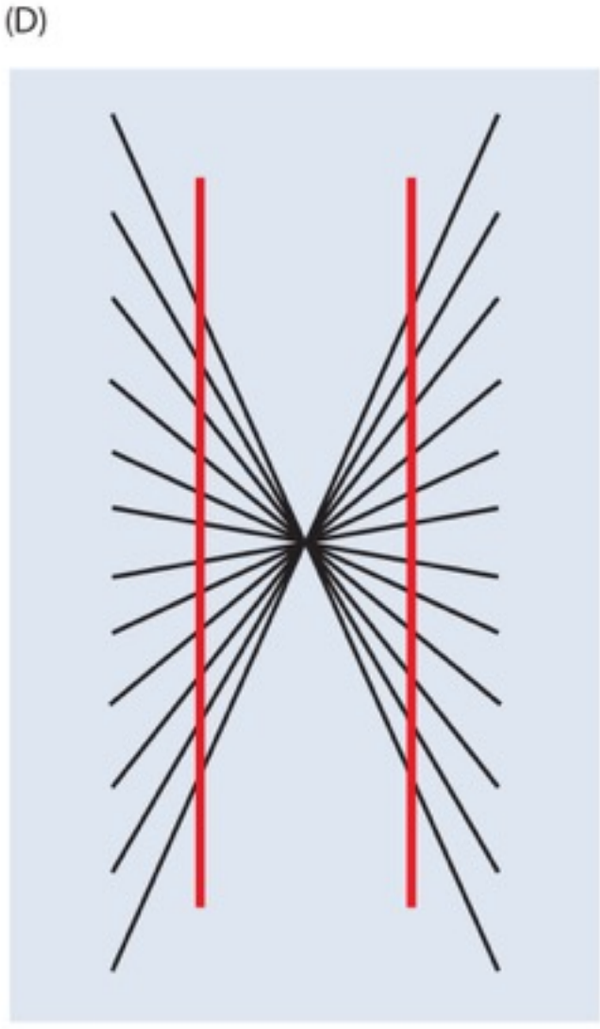
Lesson 5. Seeing Angles

Some classical anomalies in the perception of angles









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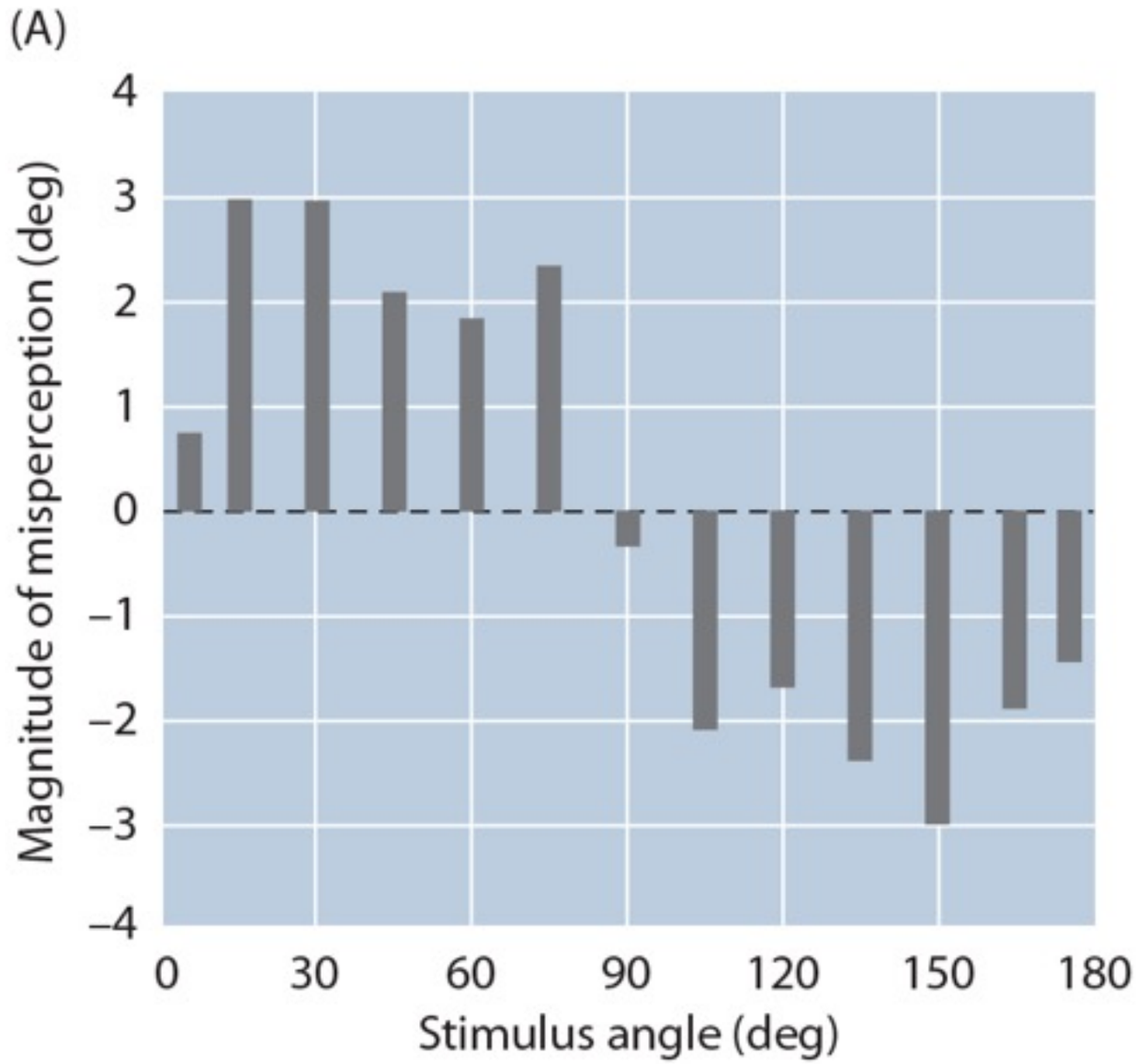
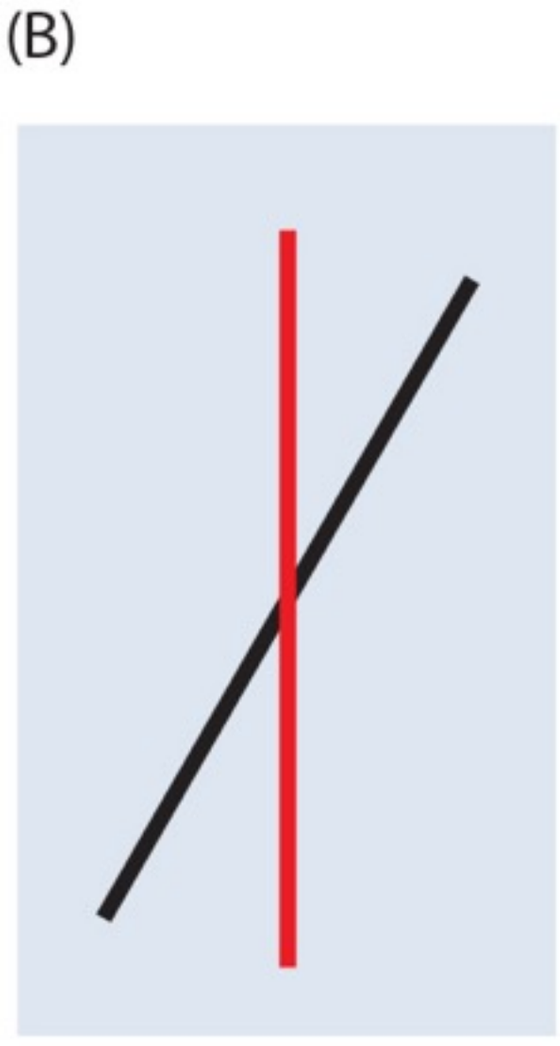
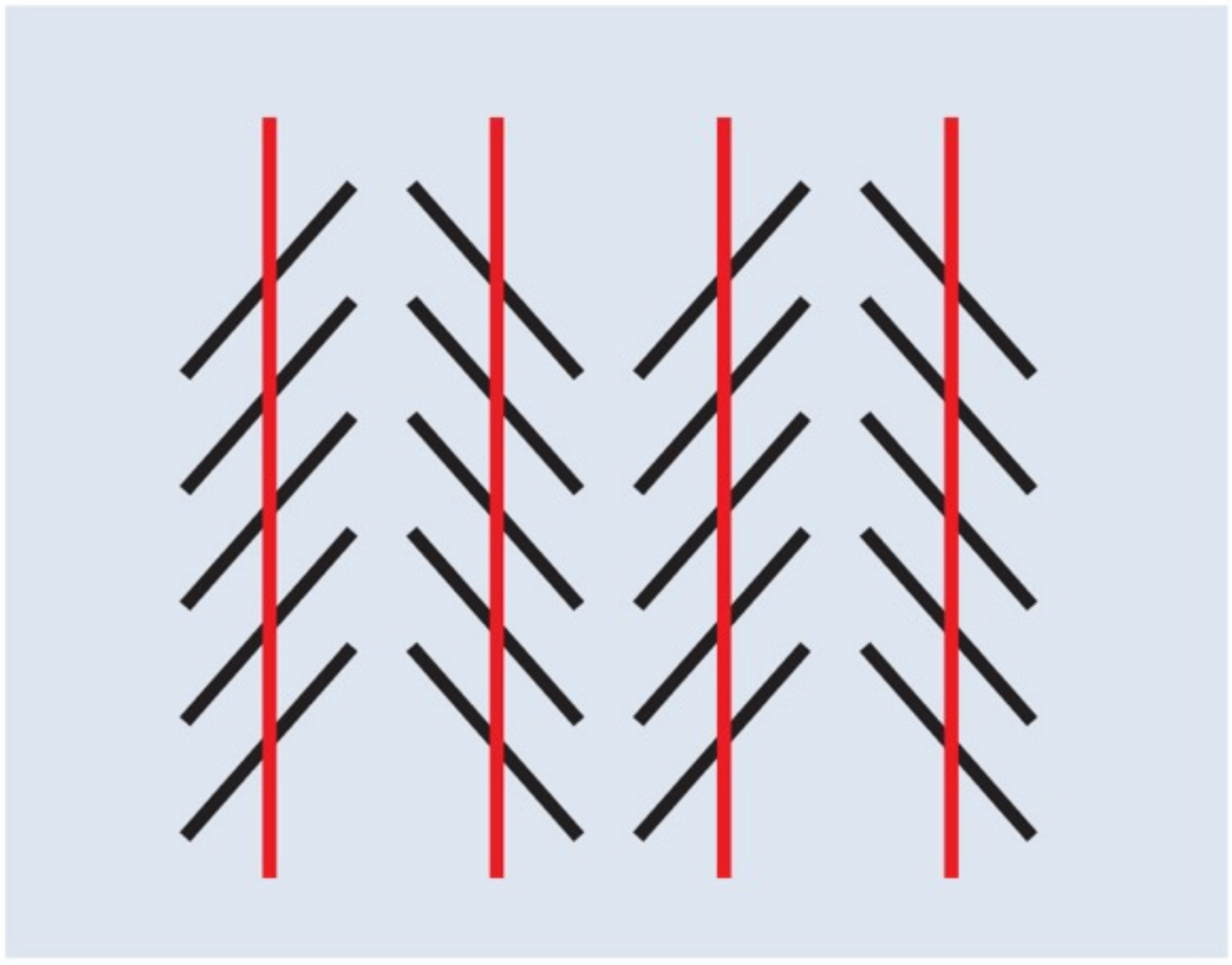


Some classical anomalies in the perception of angles



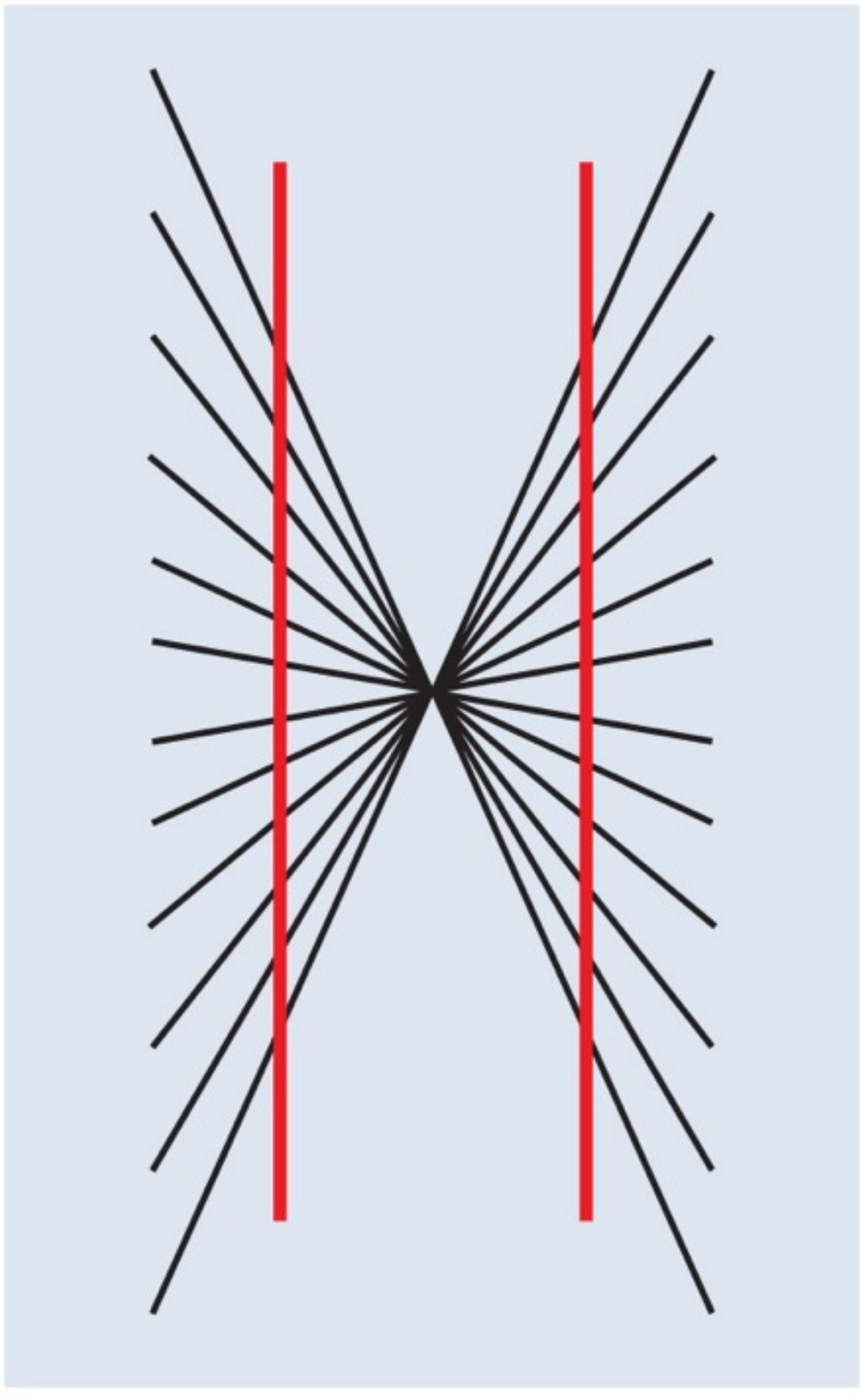
Some classical anomalies in the perception of angles

(C)



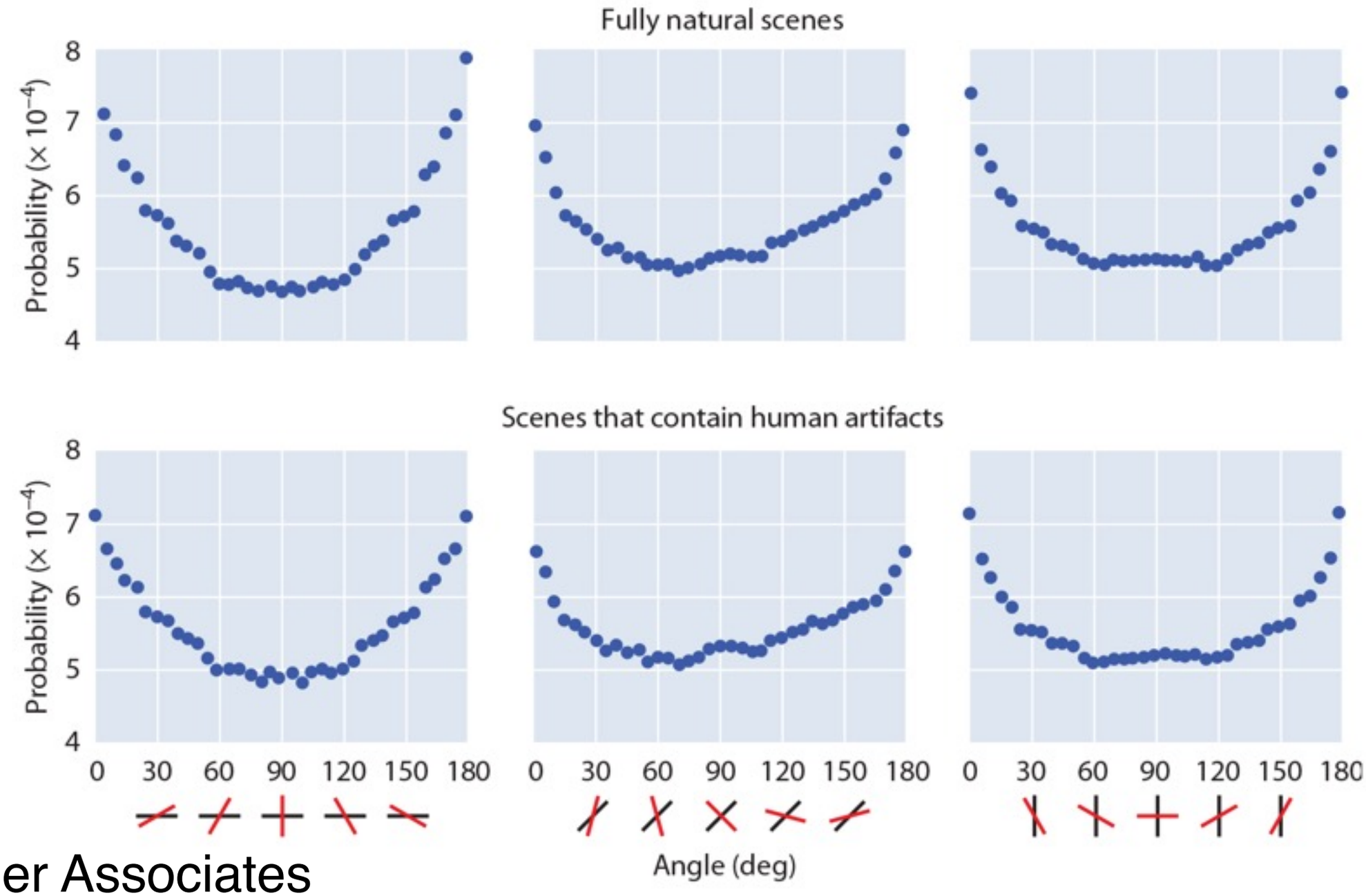
Some classical anomalies in the perception of angles

(D)



Lesson 6. An Empirical Explanation

Frequency of Occurrence of Angles



Fully natural scenes

Scenes that contain human artifacts

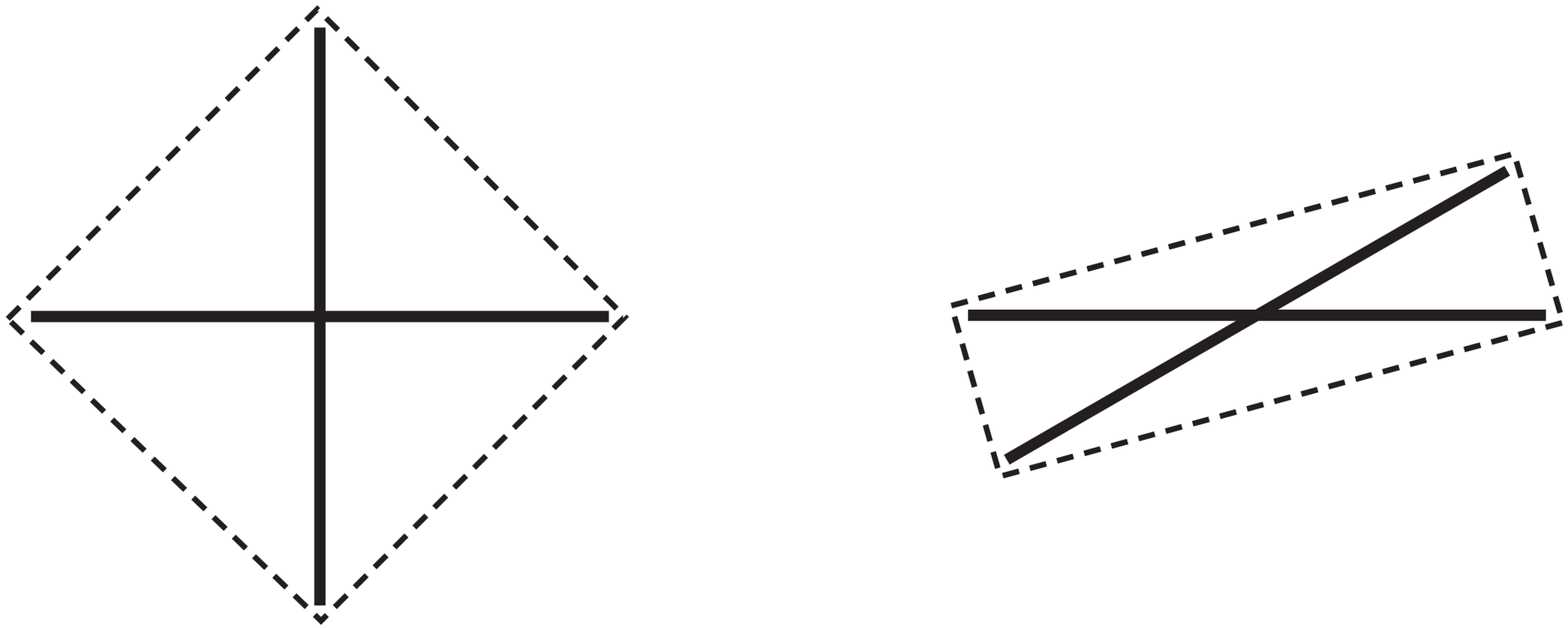
Probability ($\times 10^{-4}$)

8
7
6
5
4

0 30 60 90 120 150 180

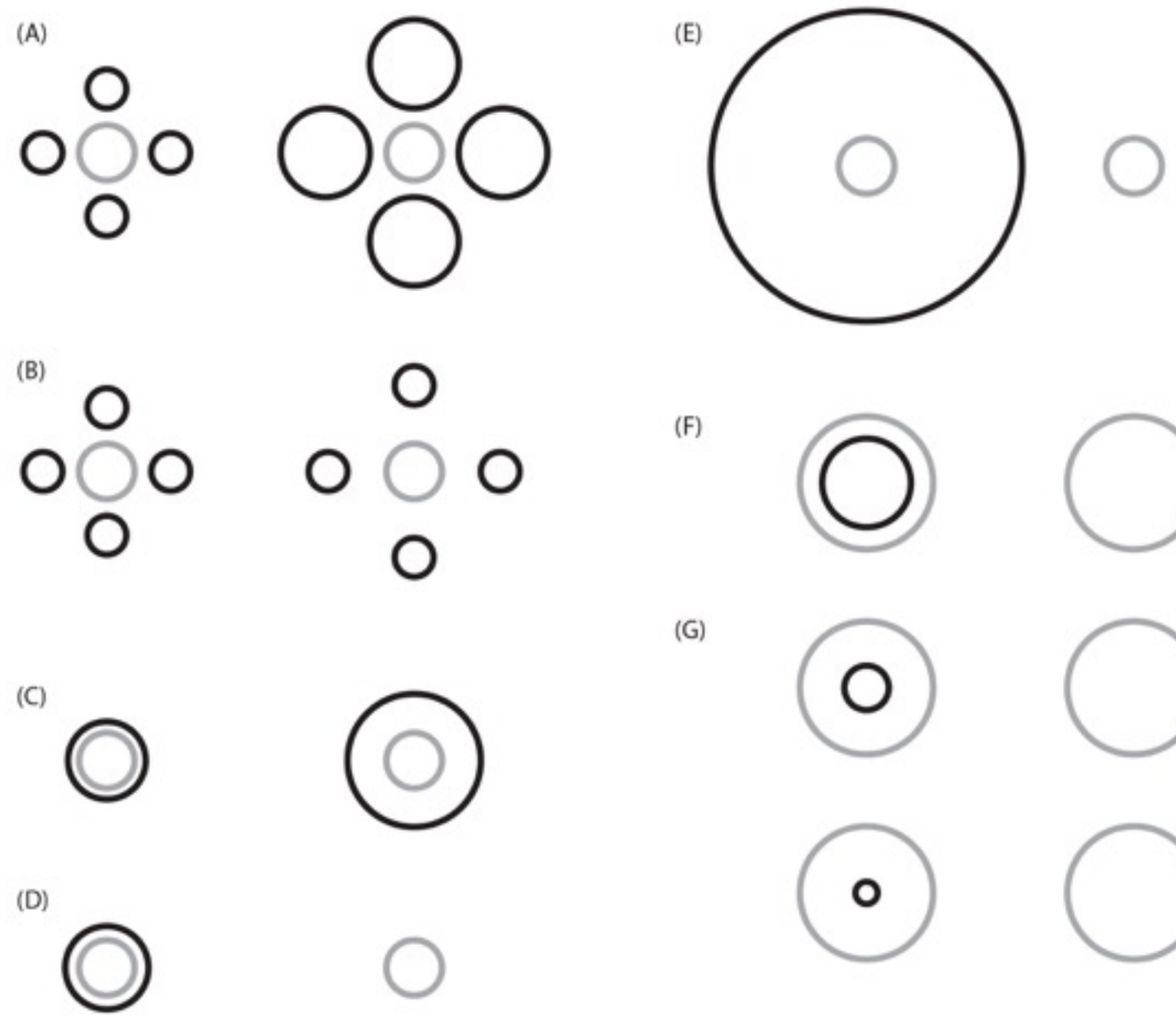
Angle (deg)

The reason

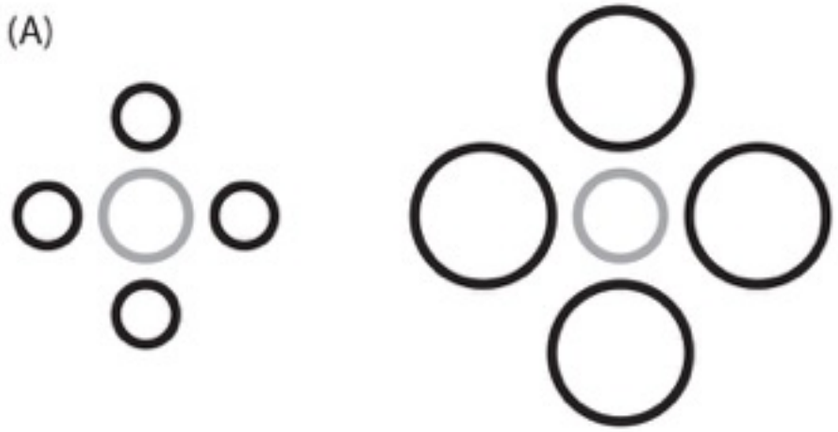


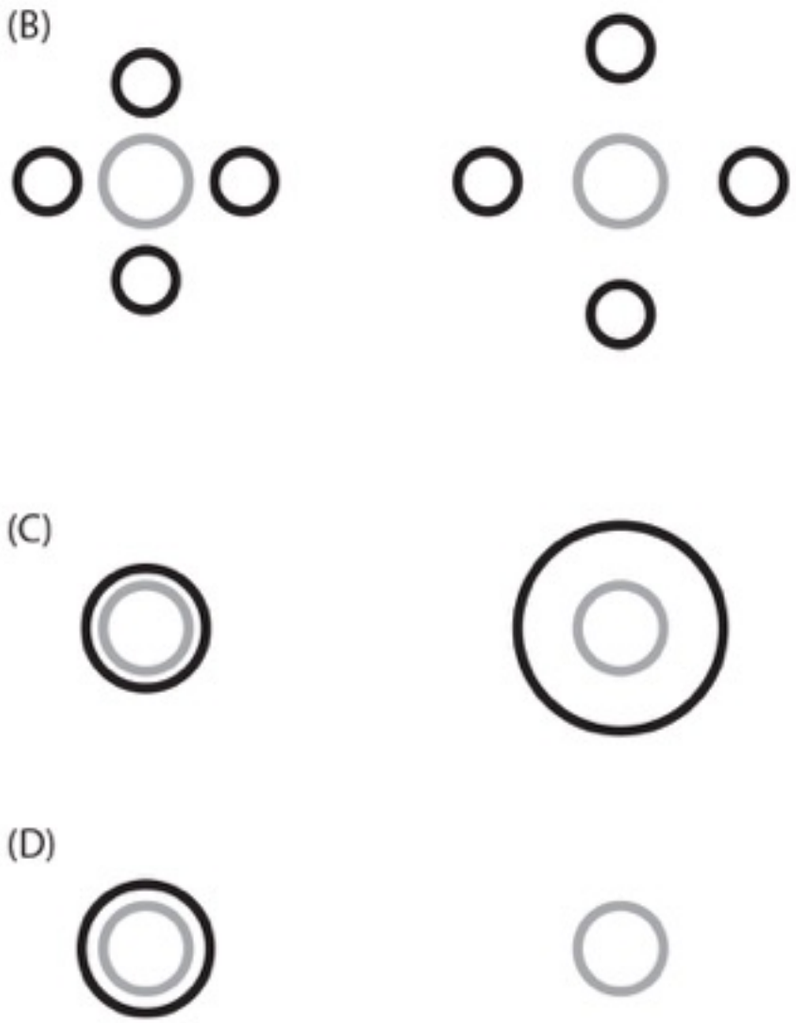
Lesson 7. Seeing Object Size

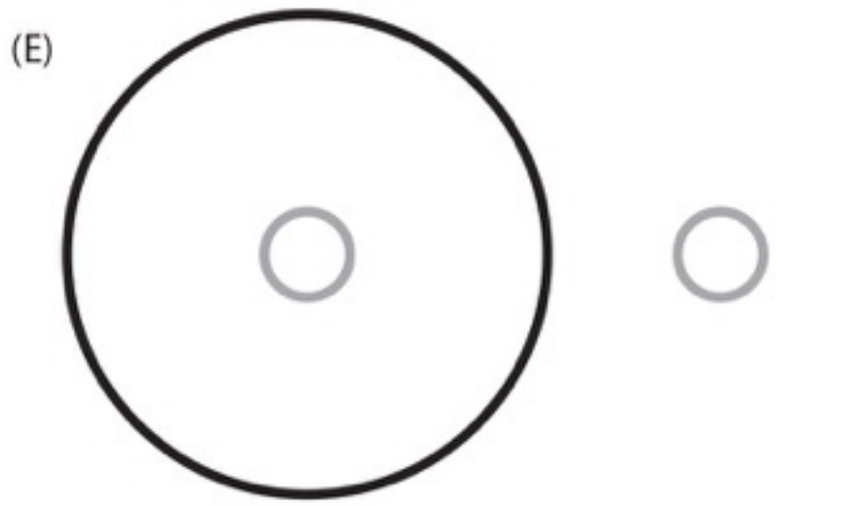
Classical size contrast effects

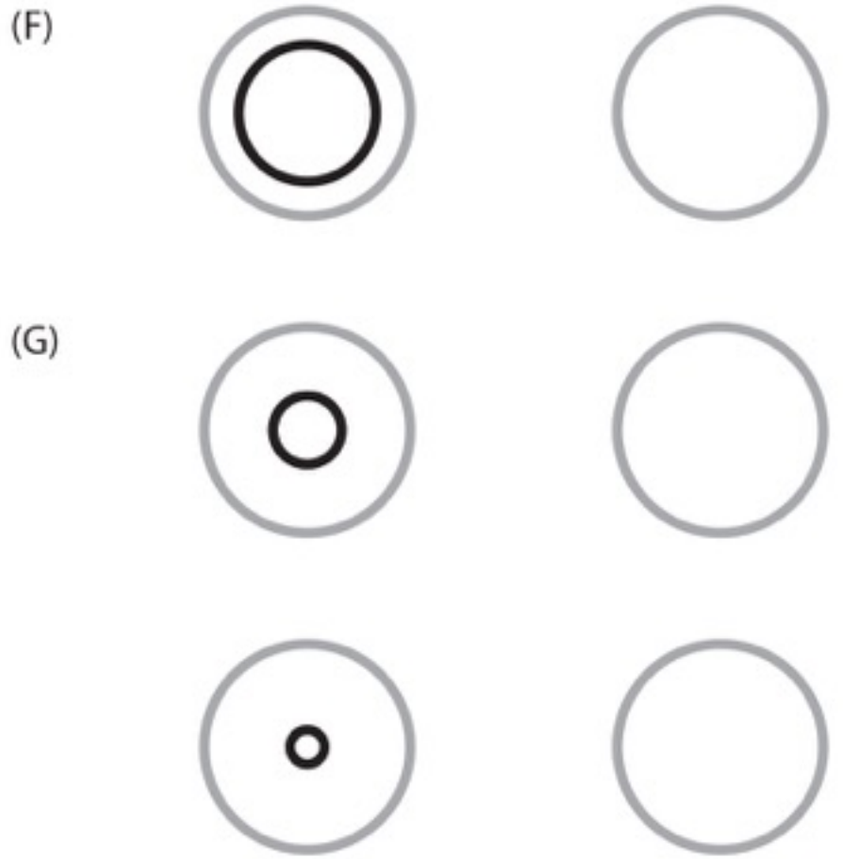


In each case the light gray circles are physically identical



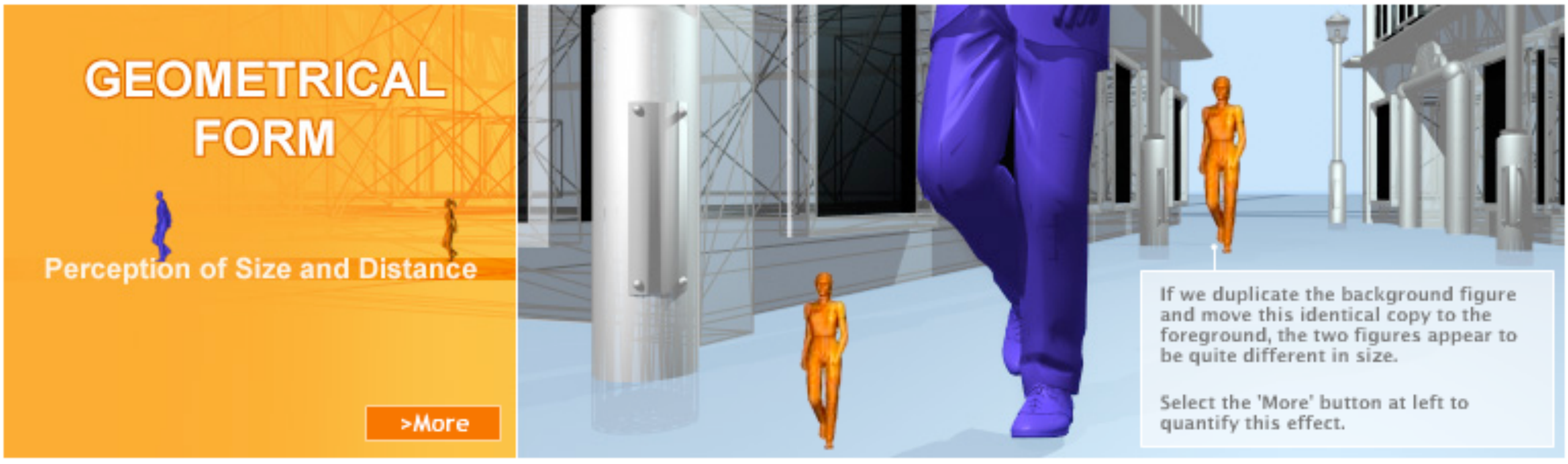






In each case the light gray circles are physically identical

A more dramatic example



purveslab.net

Lesson 8. An Empirical Explanation

Explanation of the Ebbinghaus Effect

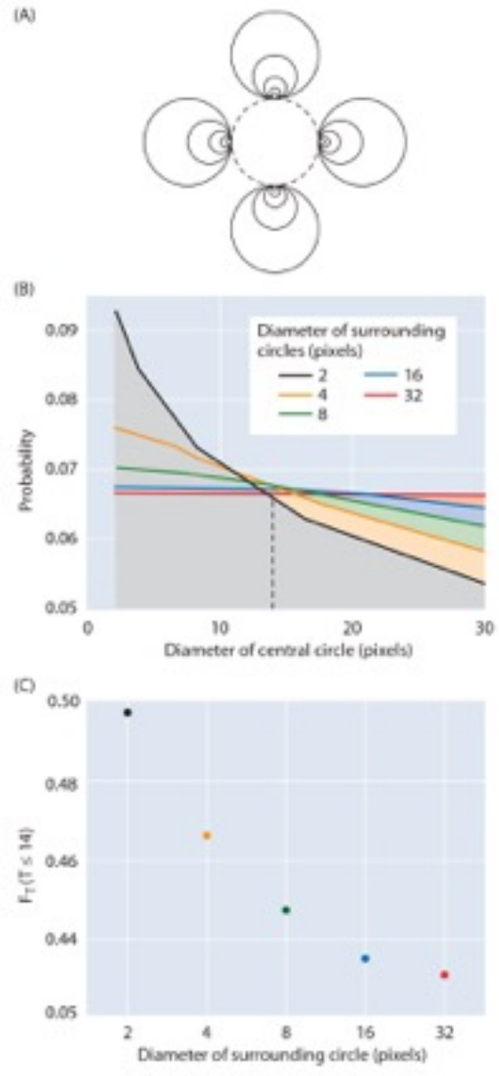
Hermann Ebbinghaus
(1850-1909)

Getting the data

The results

Occurrence of
a particular set

Example

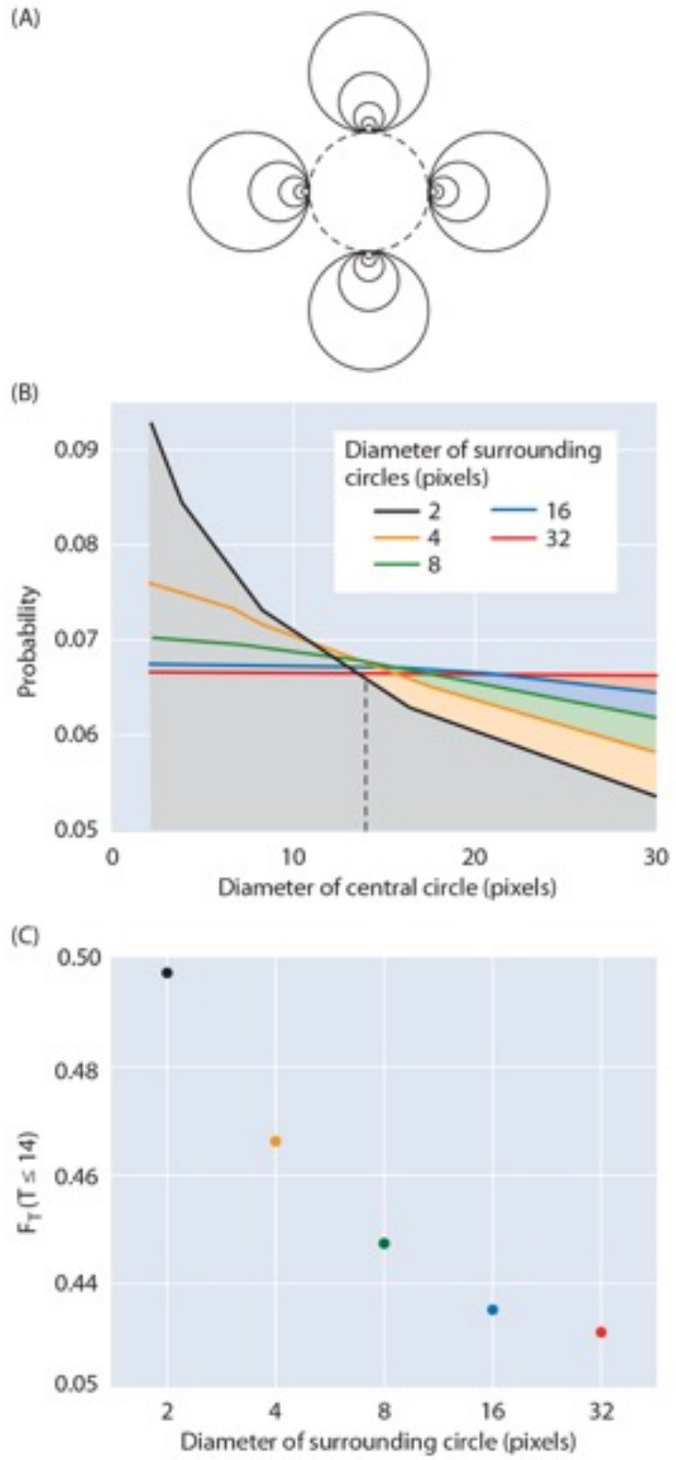


Getting the data

The results

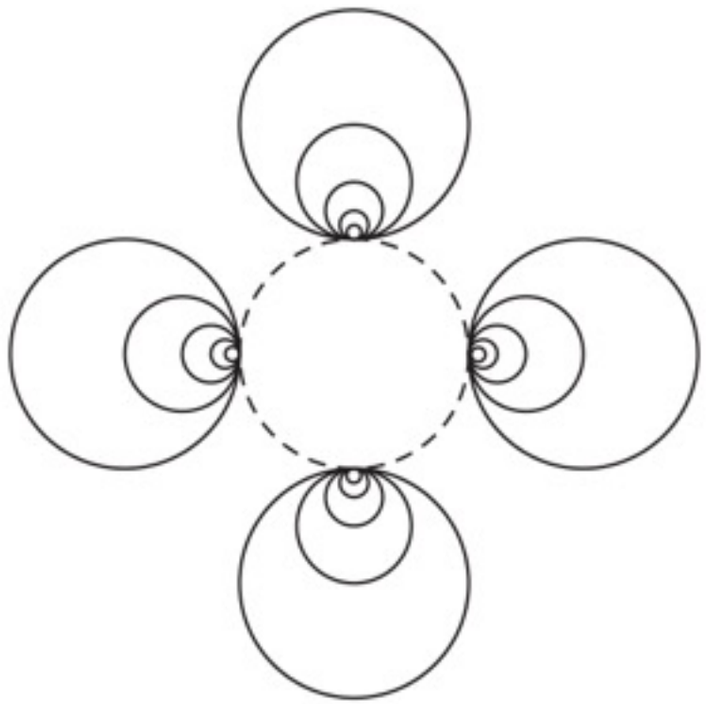
Occurrence of a particular set

Example

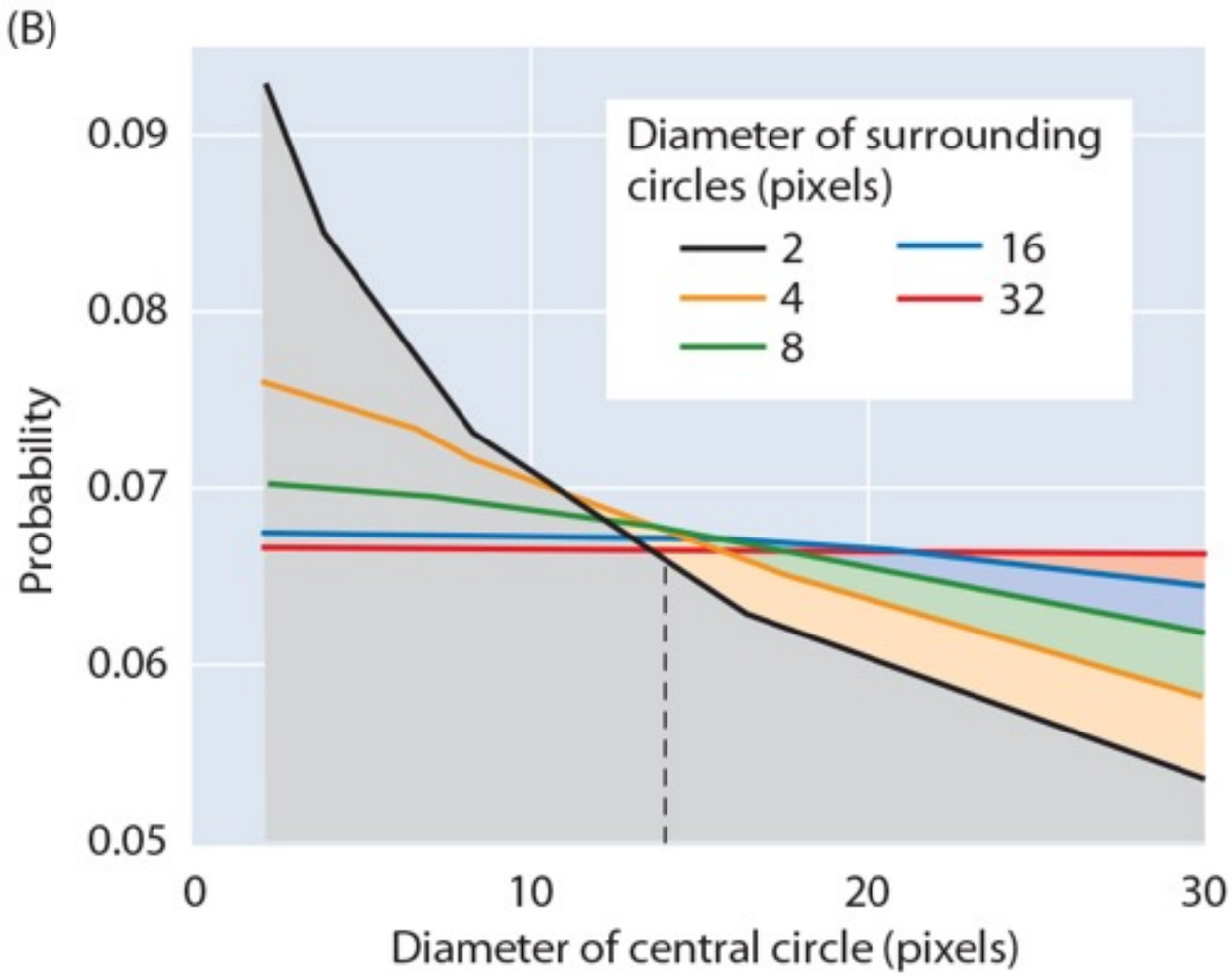


Getting the data

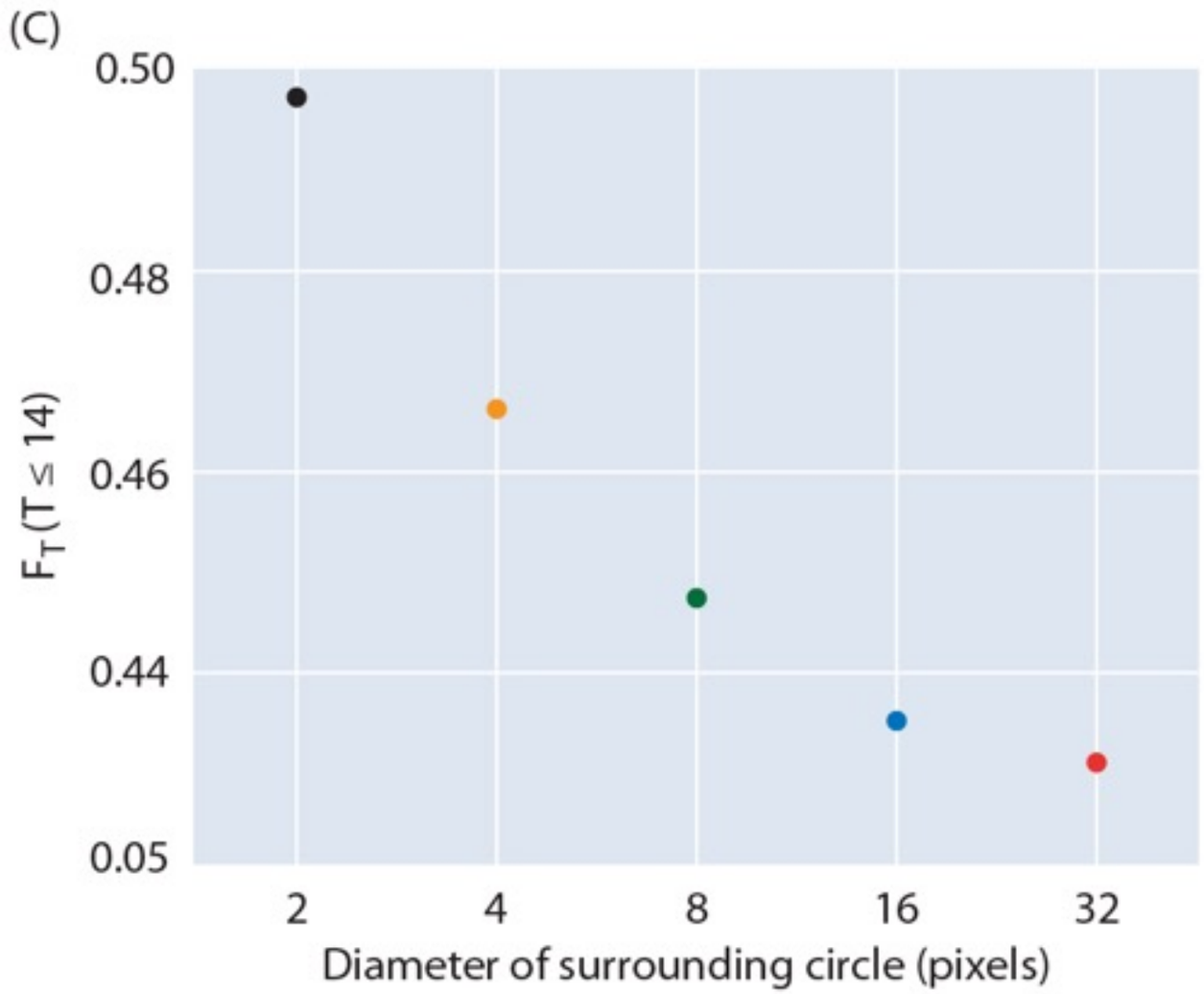
(A)



The results

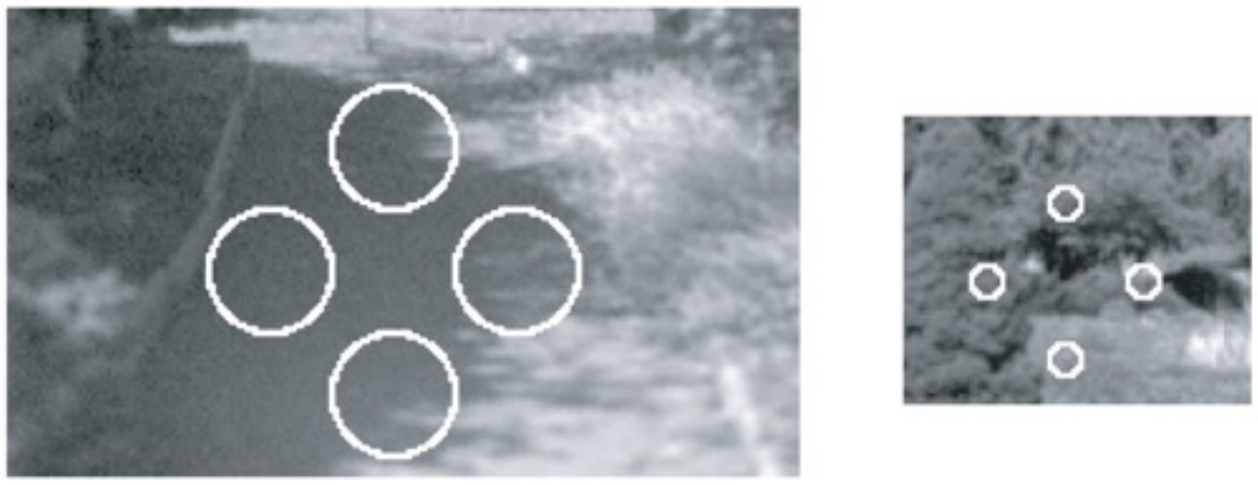


Occurrence of a particular set



Example

(D)



Summary of the Main Points

- The real-world sources of images can't be known directly; nonetheless, we must behave in terms of the real world and it properties
- The apparent solution we are going to consider is that percepts are *not* generated on the basis of feature detection and representation, but on the basis of accumulated trial and error experience
- The evidence is that much of what we see can be explained on this basis
- If this interpretation is correct, then visual cortical circuitry and it purposes will have to be understood in these terms

Credits

Geometrical illusions, Dale Purves, R. Beau Lotto. *Why We See What We Do Redux*, Sinauer Associates Inc. 2011, pg. 93

Perceiving angles, Dale Purves, R. Beau Lotto. *Why We See What We Do*, Sinauer Associates Inc. 2003, pg. 153

Müller-Lyer effect, Dale Purves, R. Beau Lotto. *Why We See What We Do Redux*, Sinauer Associates Inc. 2011, pg. 121

Müller-Lyer effect in the real world, Howe CQ, Purves D (2005) *Perceiving Geometry: Geometrical Illusions Explained by Natural Scene Statistics*. New York, NY: Springer.

Perceiving geometrical stimuli, Dale Purves, R. Beau Lotto. *Why We See What We Do Redux*, Sinauer Associates Inc. 2011, pg. 92

"Lincoln Hat" illusion, ©2014 Dale Purves

Perception of line length, Dale Purves, R. Beau Lotto. *Why We See What We Do Redux*, Sinauer Associates Inc. 2011, pg. 99

Scanner photo and sample scans, ©2014 Dale Purves

Credits, Cont.

Dale Purves, R. Beau Lotto. *Why We See What We Do Redux*, Sinauer Associates Inc. 2011

- Oriented lines, pg. 100
- Results of the analysis, pg. 101
- Perception of line length as function of orientation, pg. 102
- Line perception anomalies, pg. 106
- Frequency of projected angles, pg. 108
- 90-degree and non-90-degree angles, pg. 108
- Classical size contrast effects, pg. 112

Geometrical form, ©2014 Dale Purves, purveslab.net

Ebbinghaus effect, Dale Purves, R. Beau Lotto. *Why We See What We Do Redux*, Sinauer Associates Inc. 2011, pg. 114