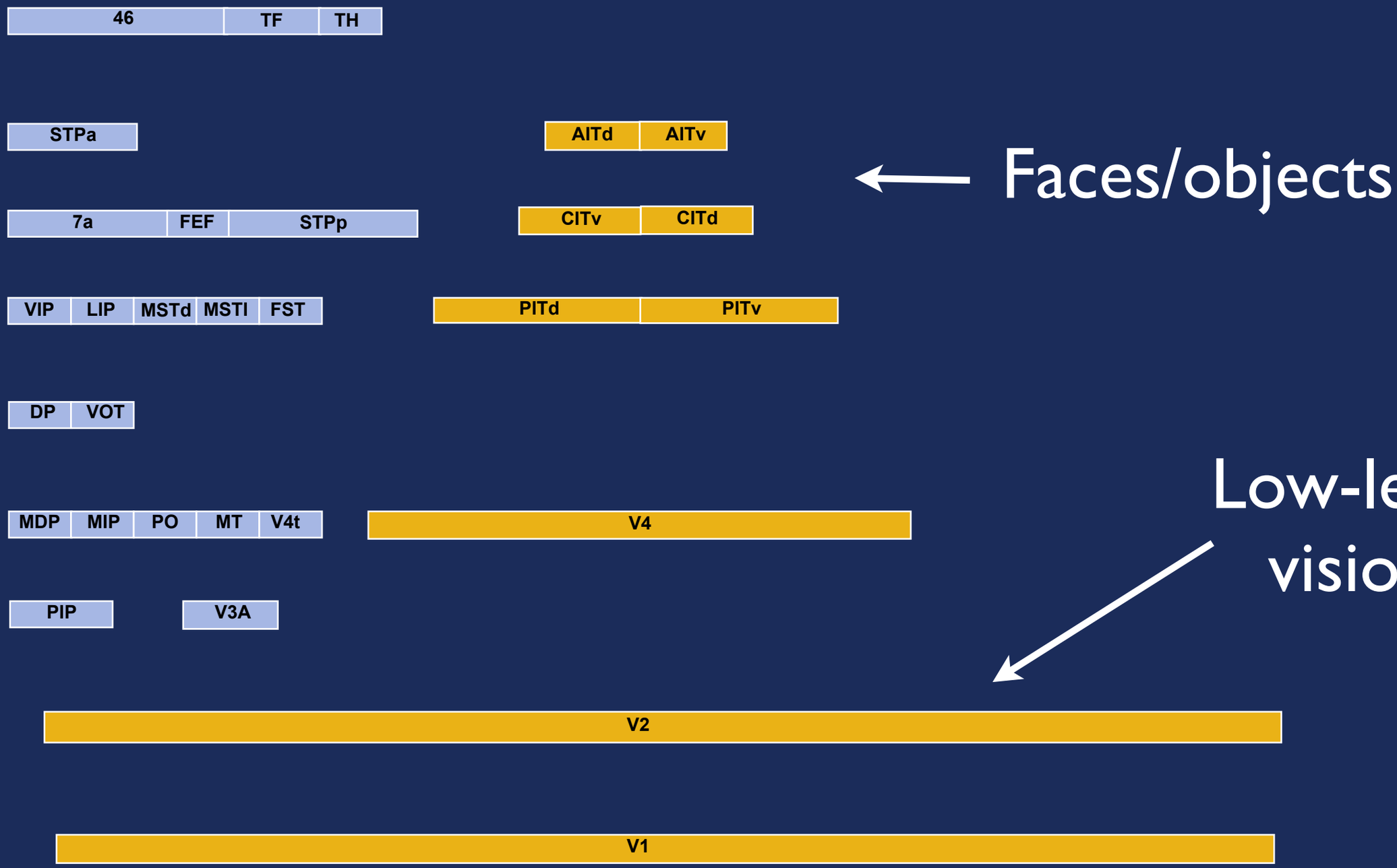
Intermediate-level vision

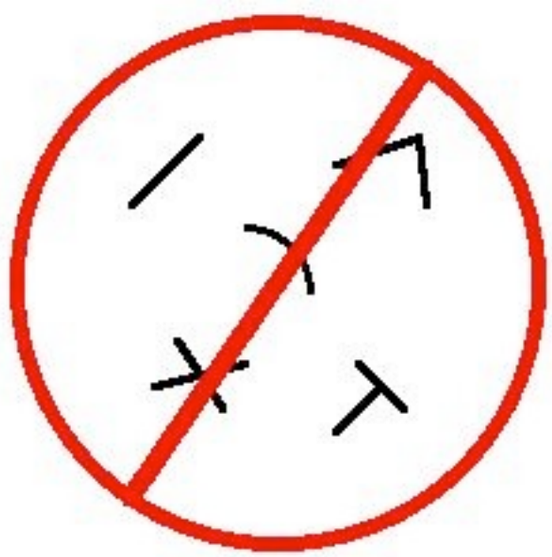
Visual cortical areas



(courtesy of Jeff Hawkins)

Visual representations are 3D, not 2D

Nakayama K, He ZJ, and Shimojo S. (1995) Visual surface representation: a critical link between lower-level and higher level vision. In: S.M. Kosslyn and D.N. Osherson, Eds, *An Invitation to Cognitive Science*. MIT Press, pp. 1-70.



Images vs. surfaces

One of the most striking things about our visual experience is how dramatically it differs from our retinal image.

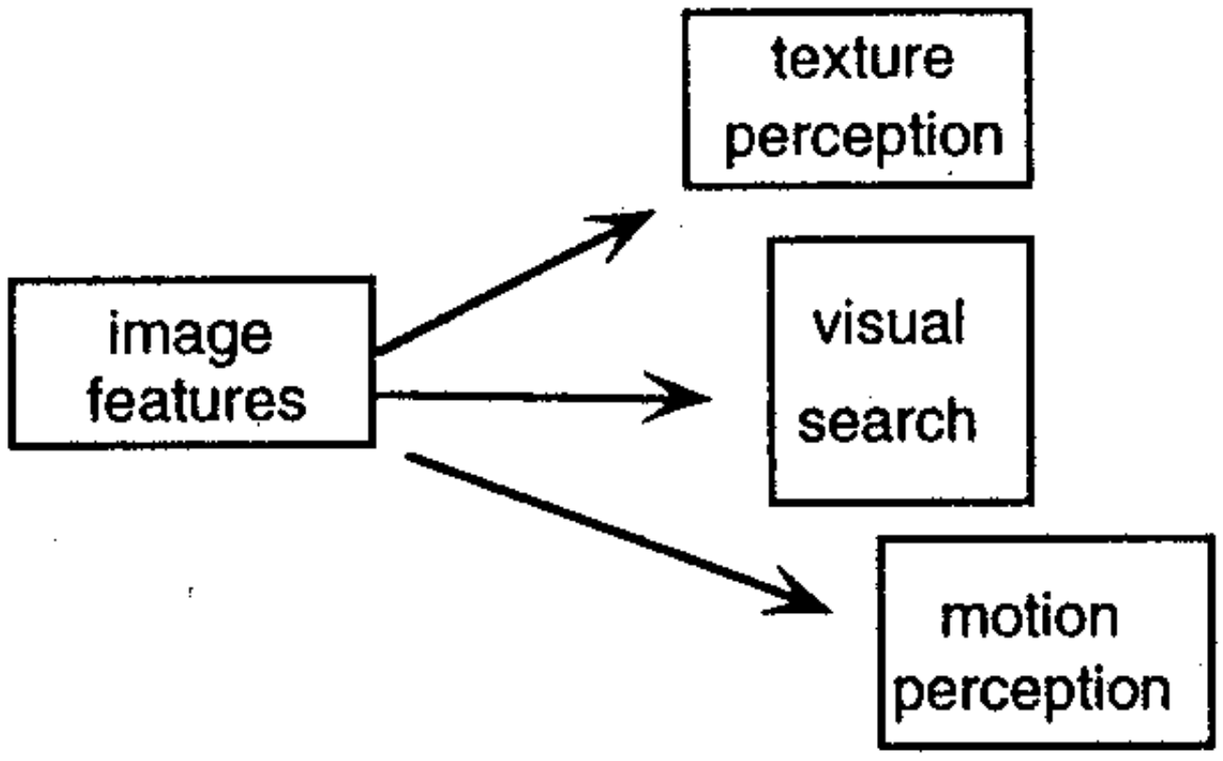
...

Our perception is closely tied to surfaces and objects in the real world; it does not seem tightly tied to our retinal images.

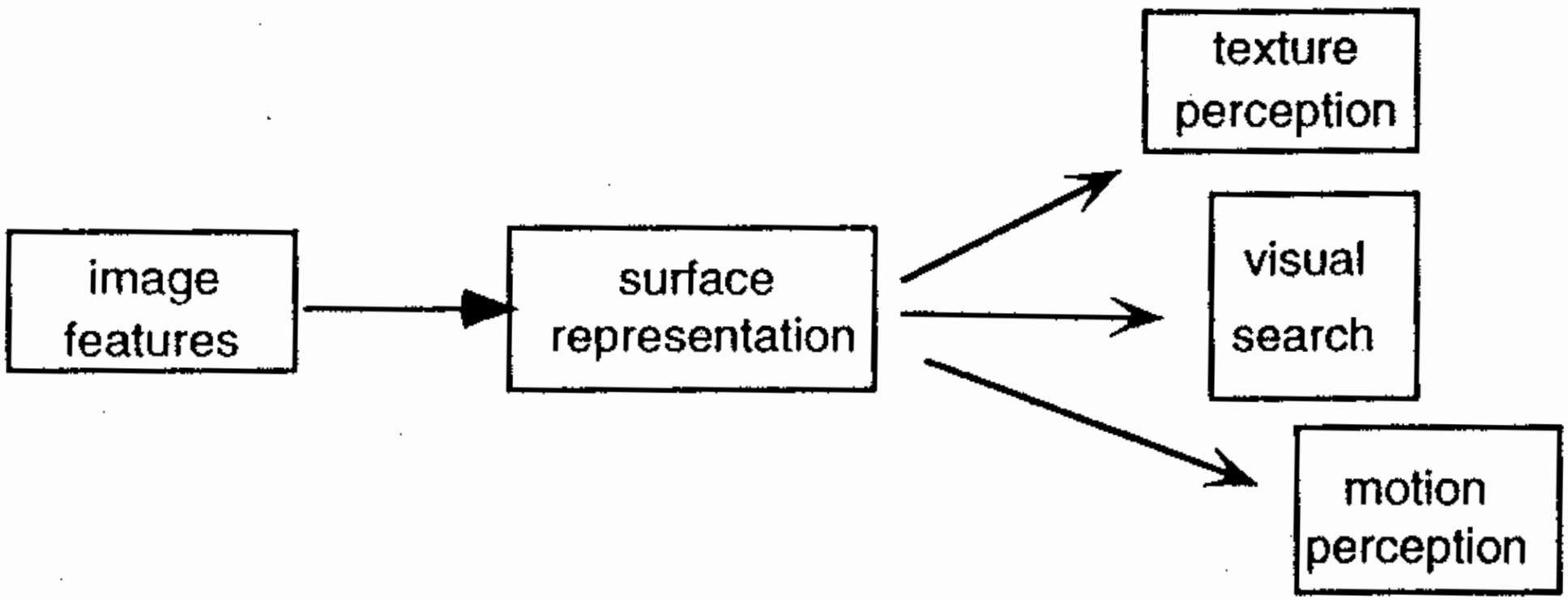
...

Our view is that higher functions require, as an input, a data format that explicitly represents the world as a set of surfaces.

The traditional view of visual processing



The new view of visual processing



How do you interpret an edge?

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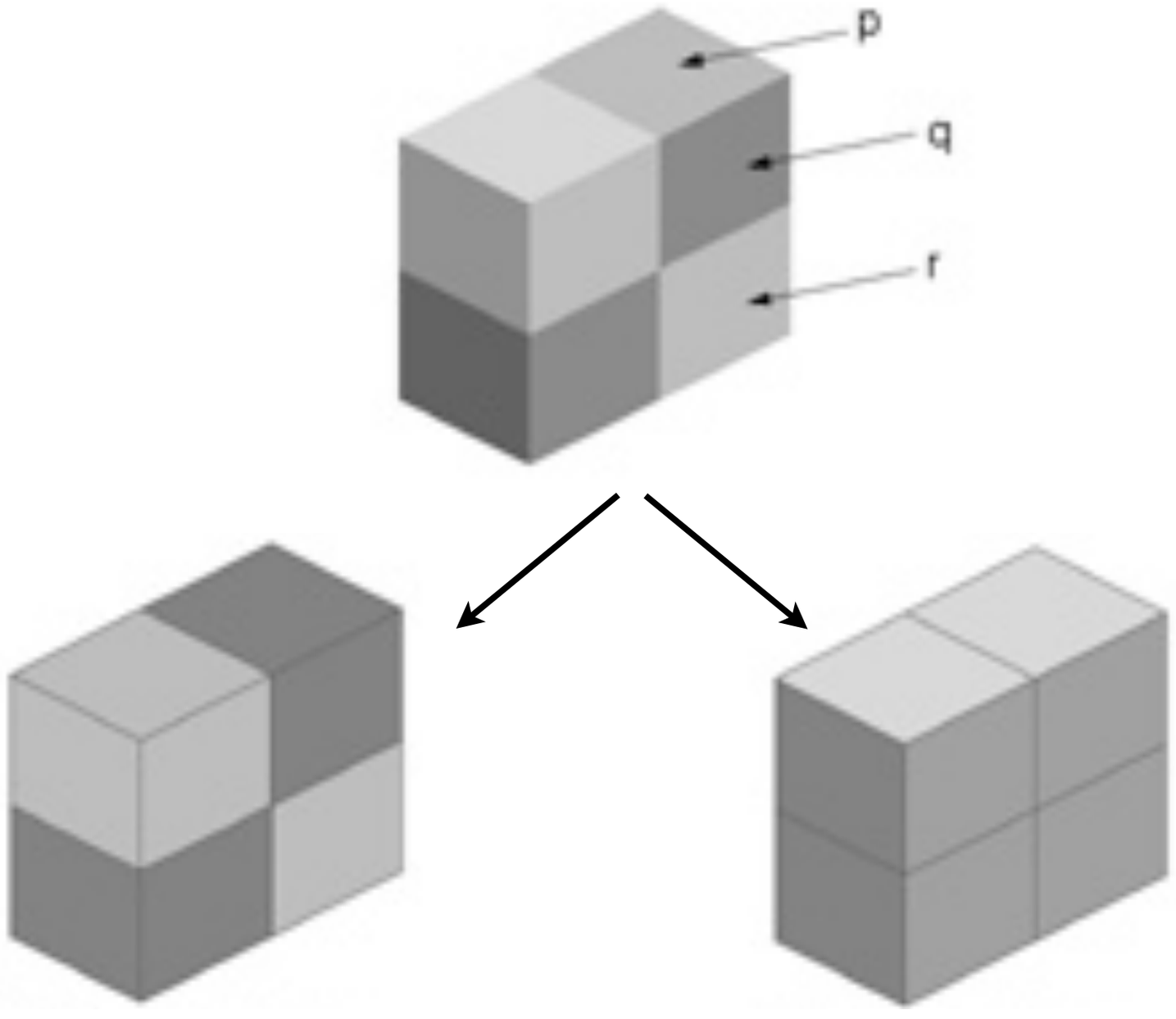
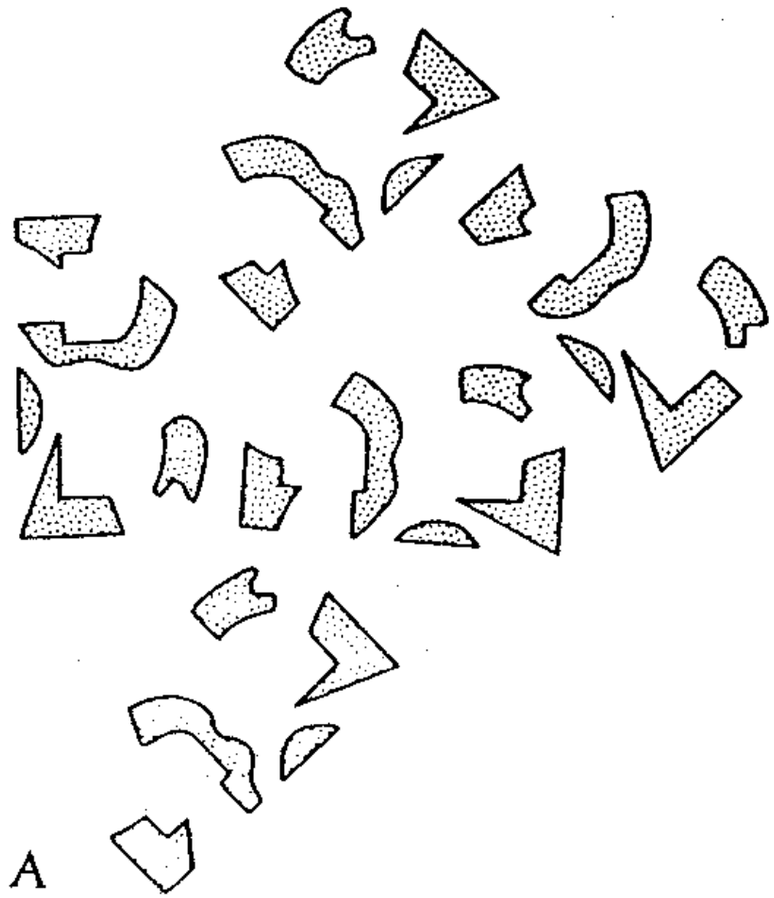
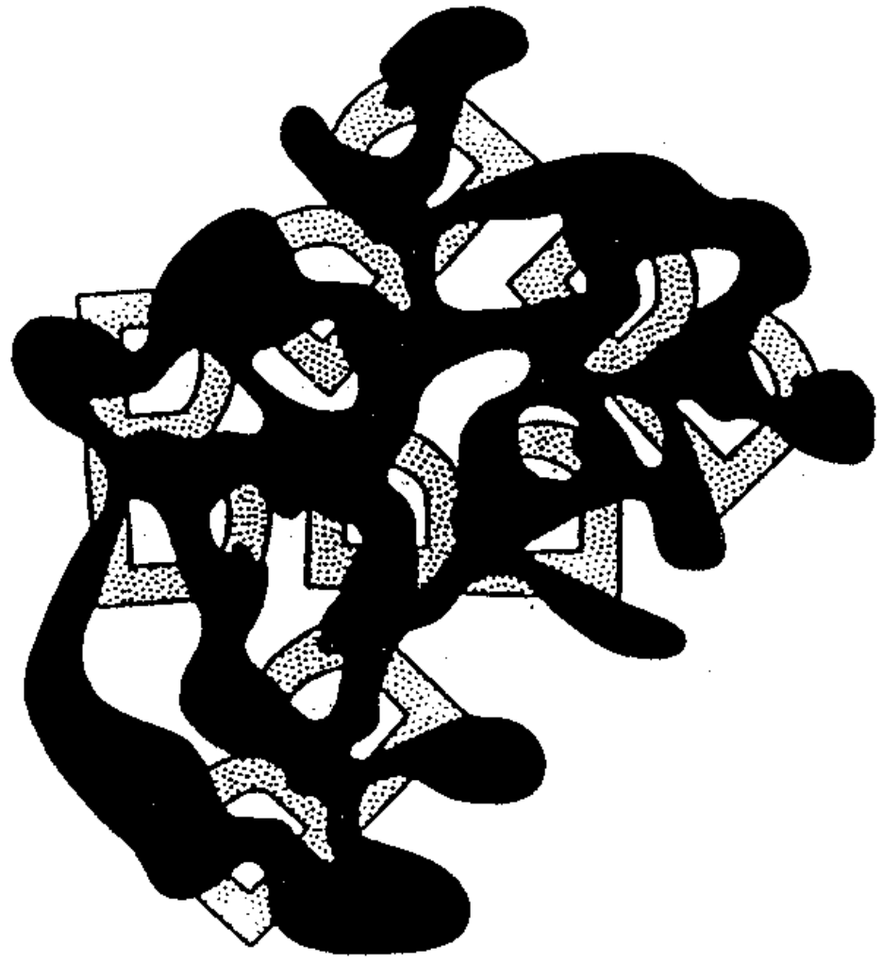
An edge can mean different things



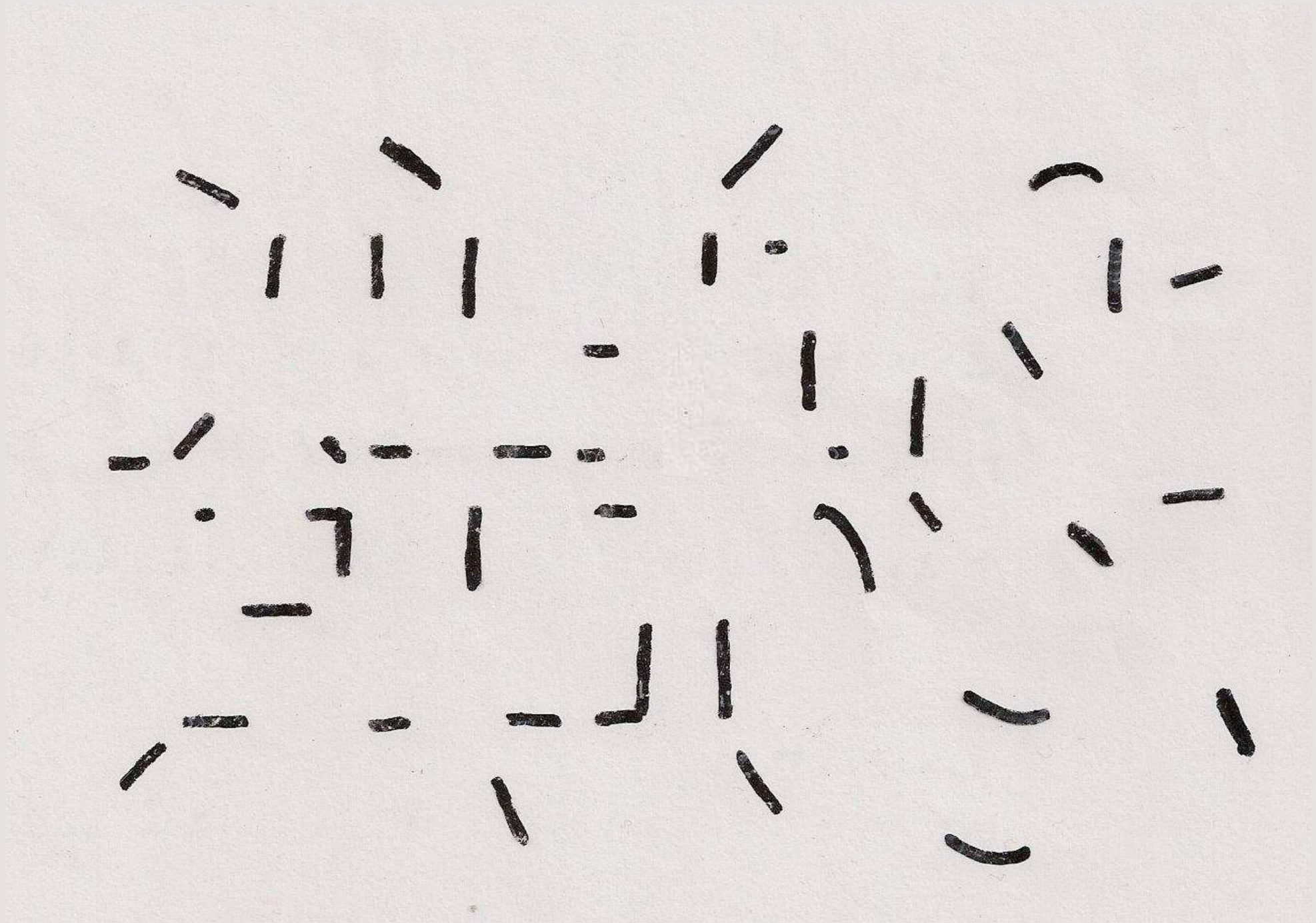
Bregman B's

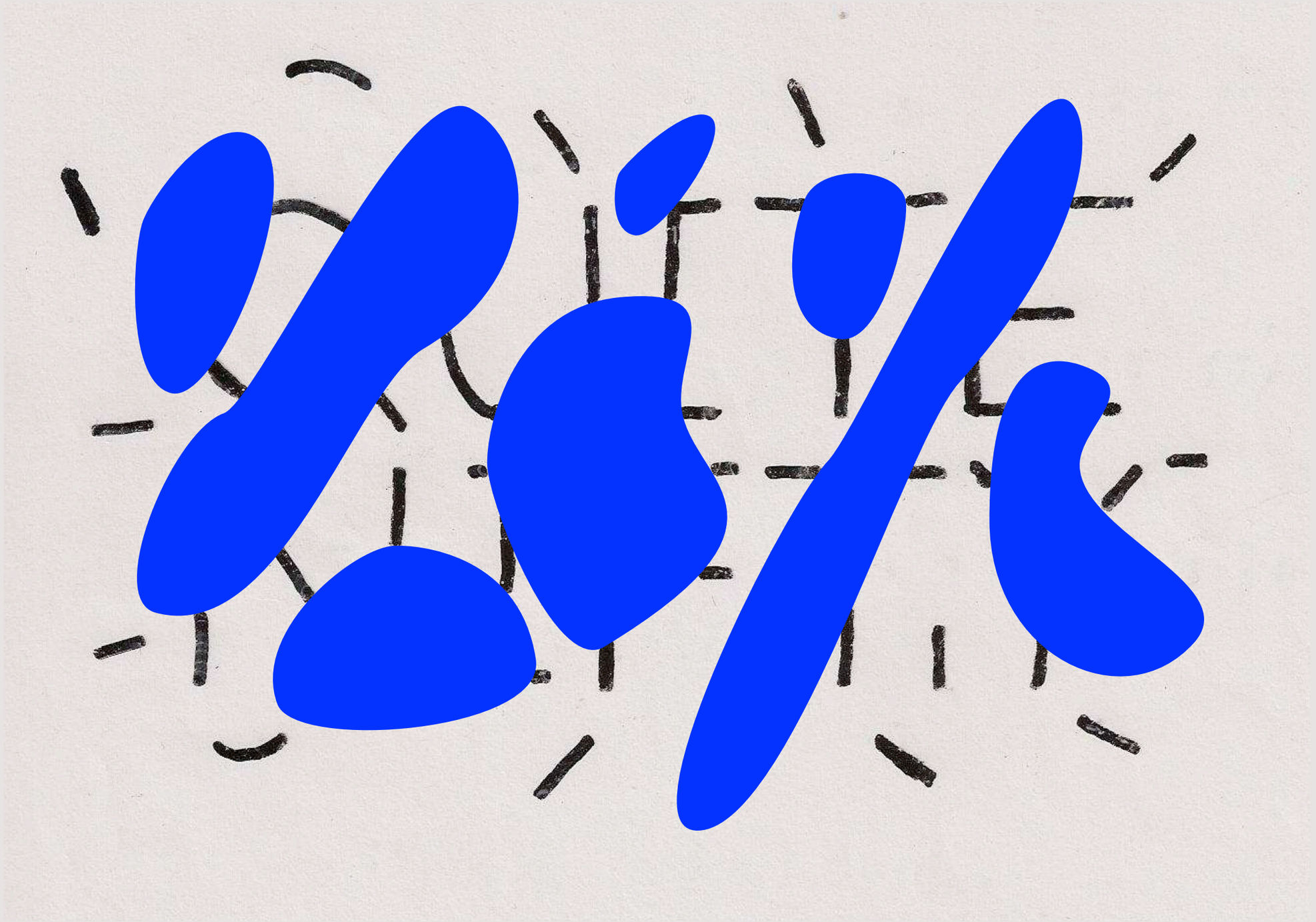


A



B





Rules of occlusion

• When image regions corresponding to different surfaces meet, only one region can "own" the border between them.

• Under conditions of surface opacity, a border is owned by the region that is coded as being in front.

• A region that does not own a border is effectively unbounded. Unbounded regions can connect to other unbounded regions to form larger surfaces completing behind.

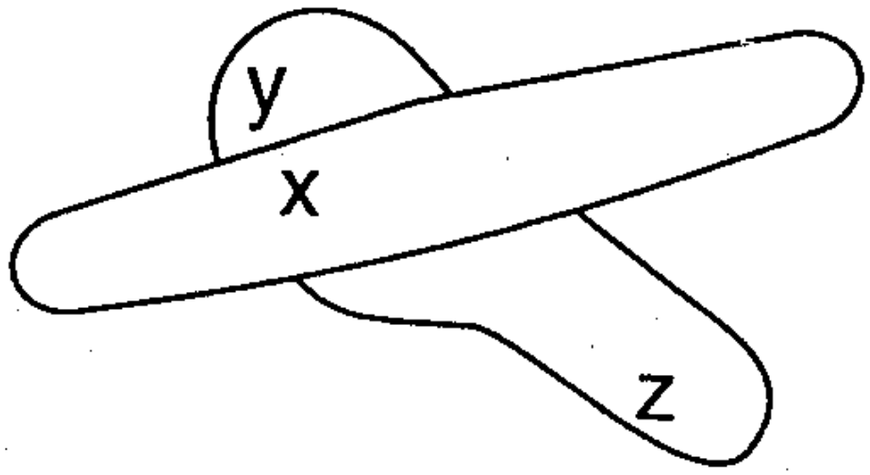
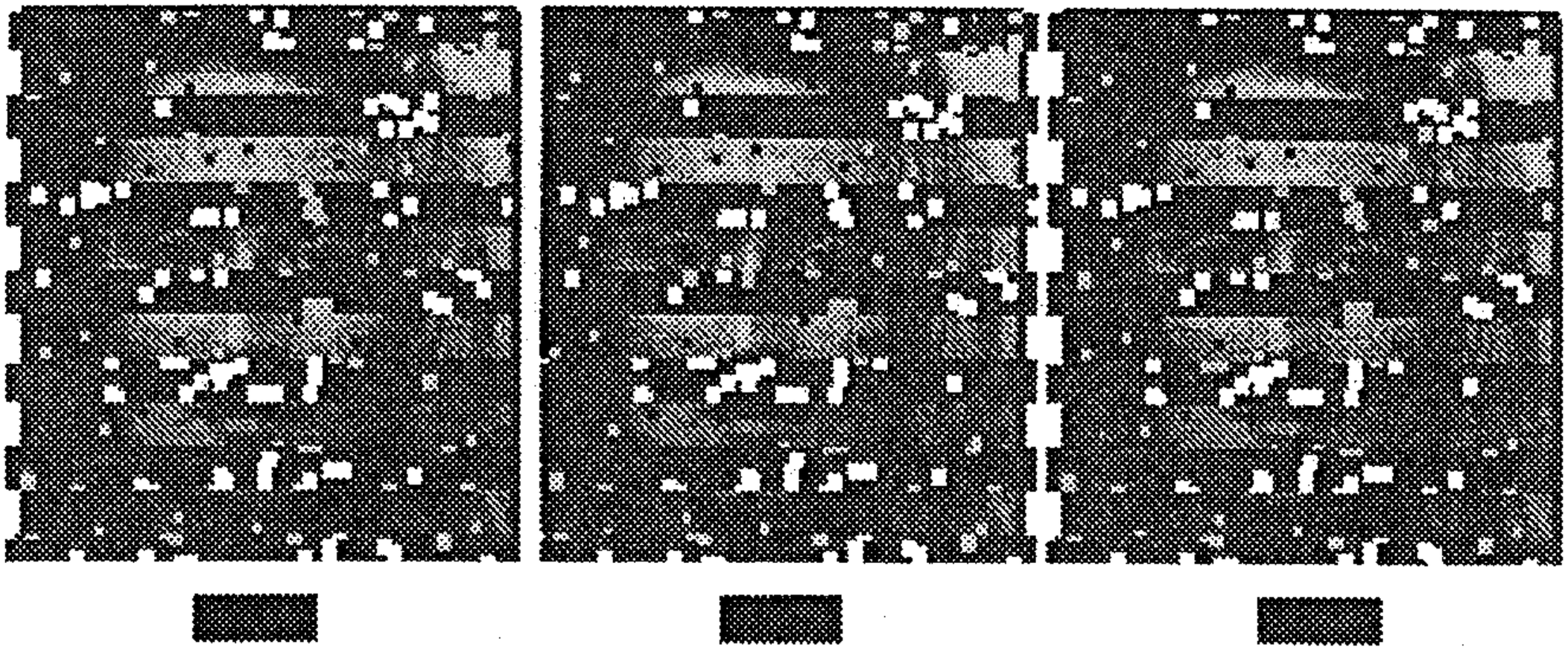
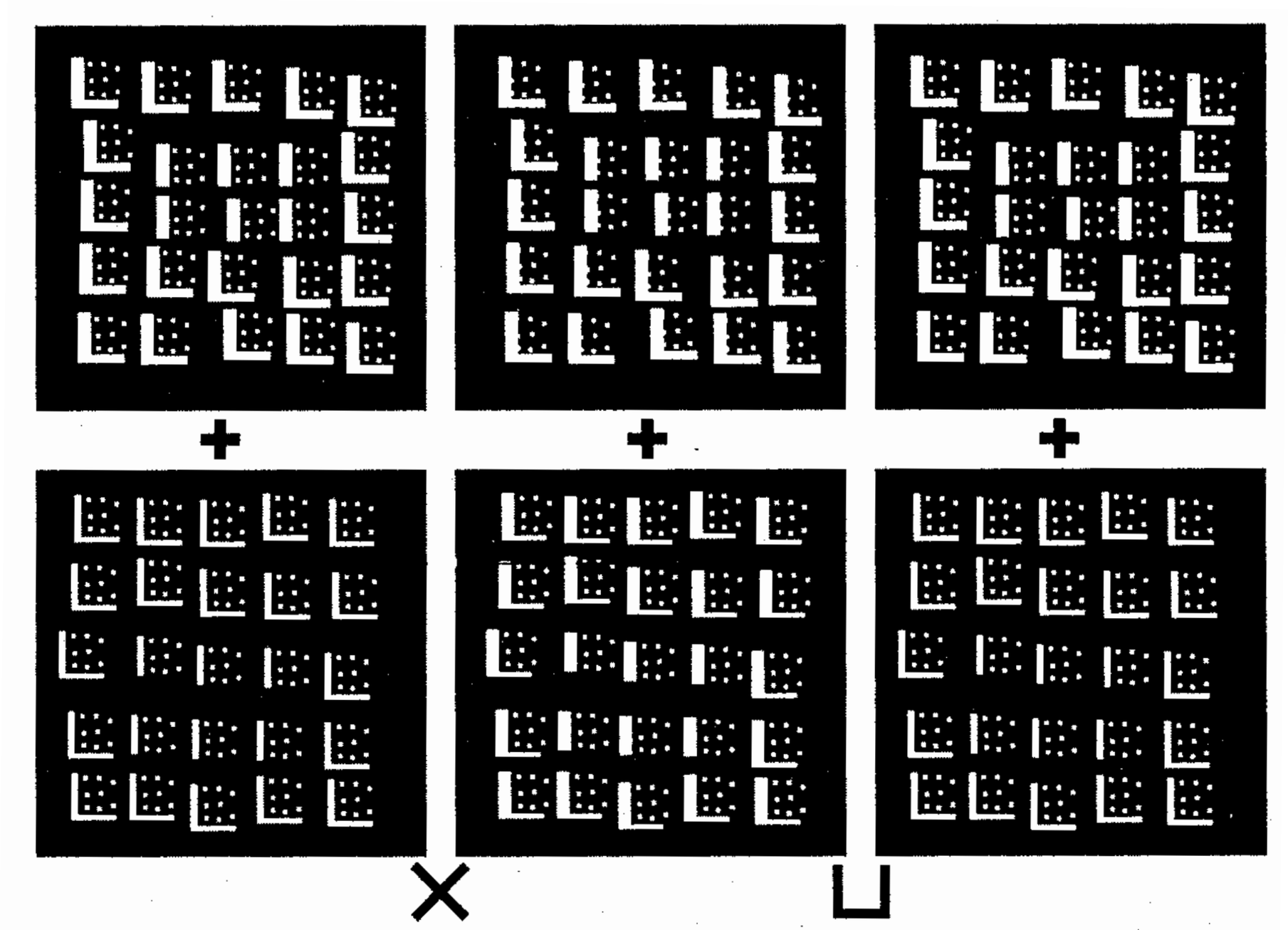
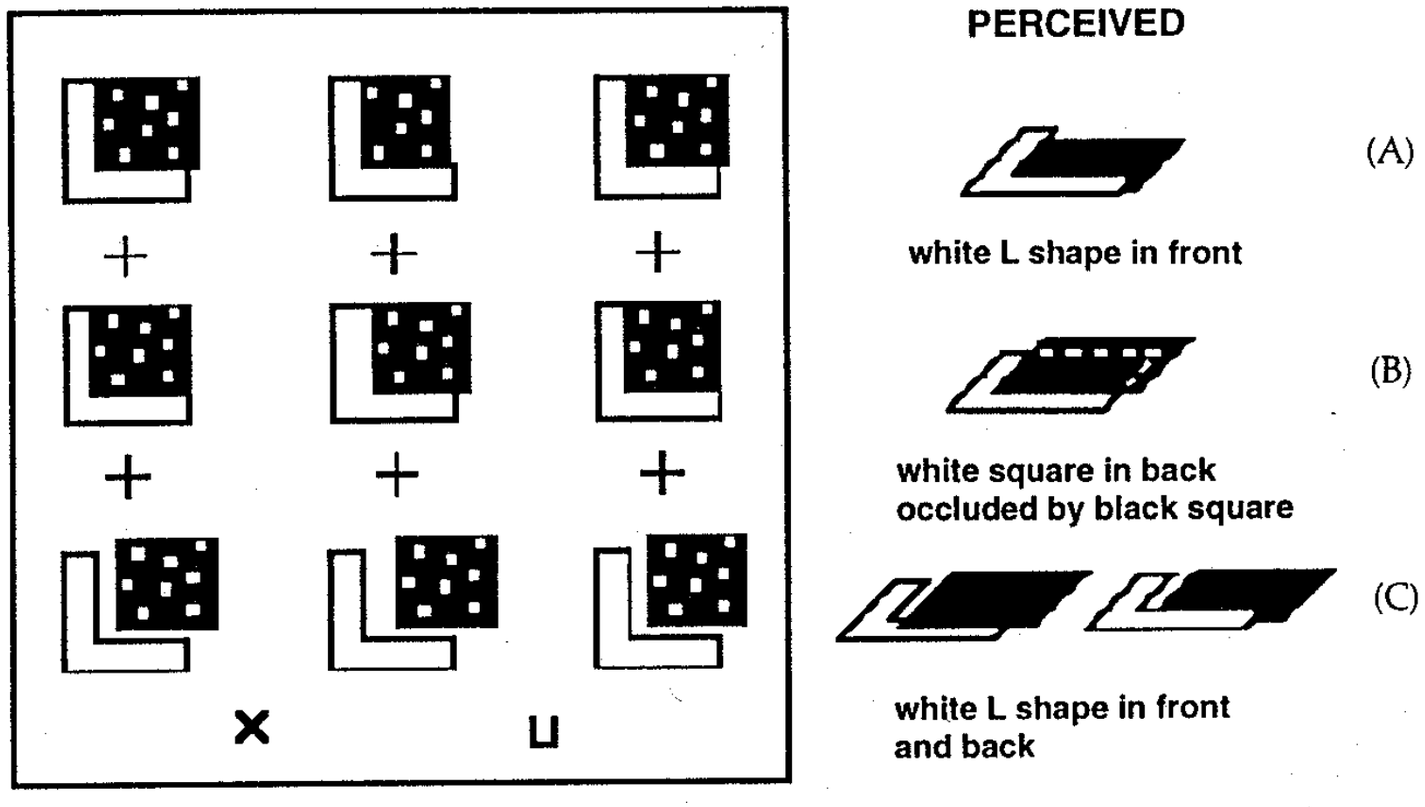


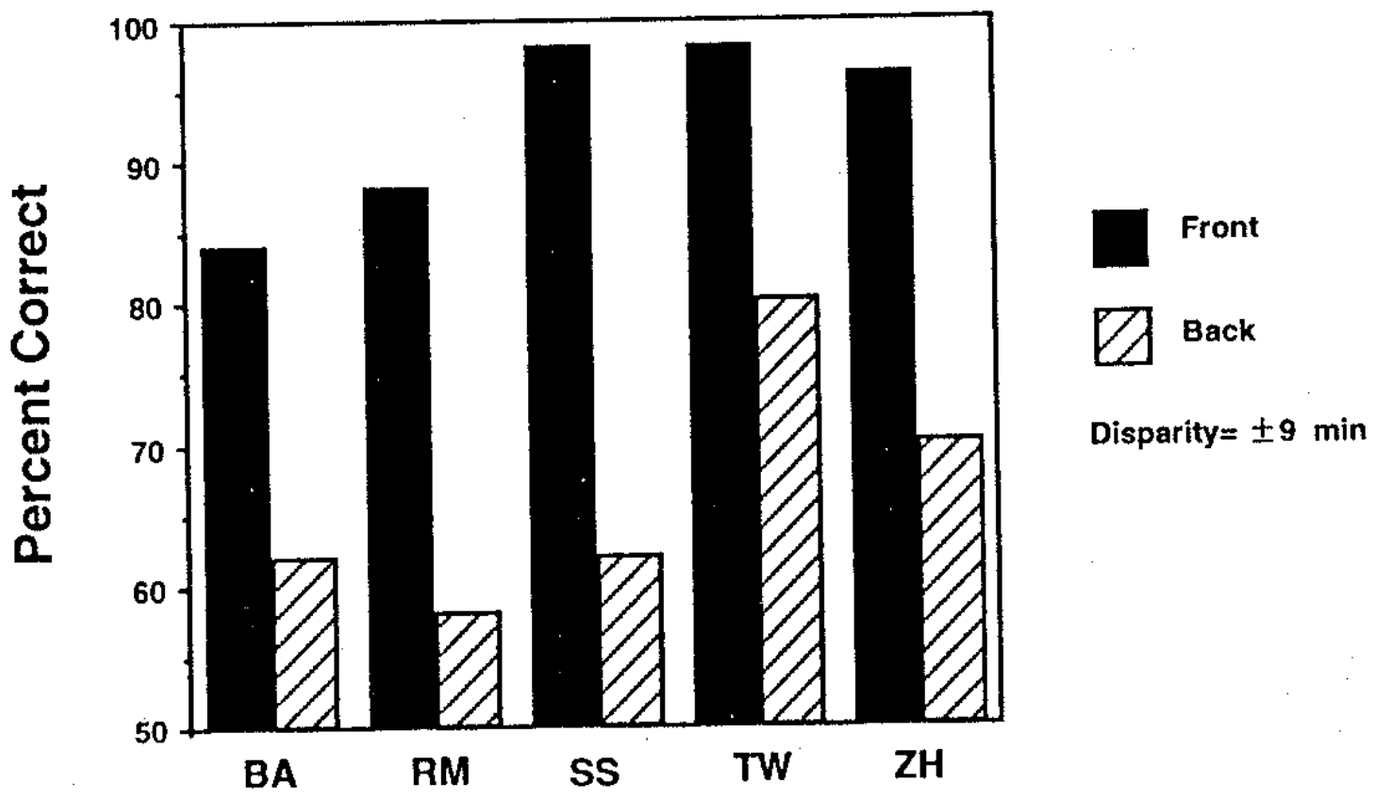
Figure-ground assignment determines amodal completion



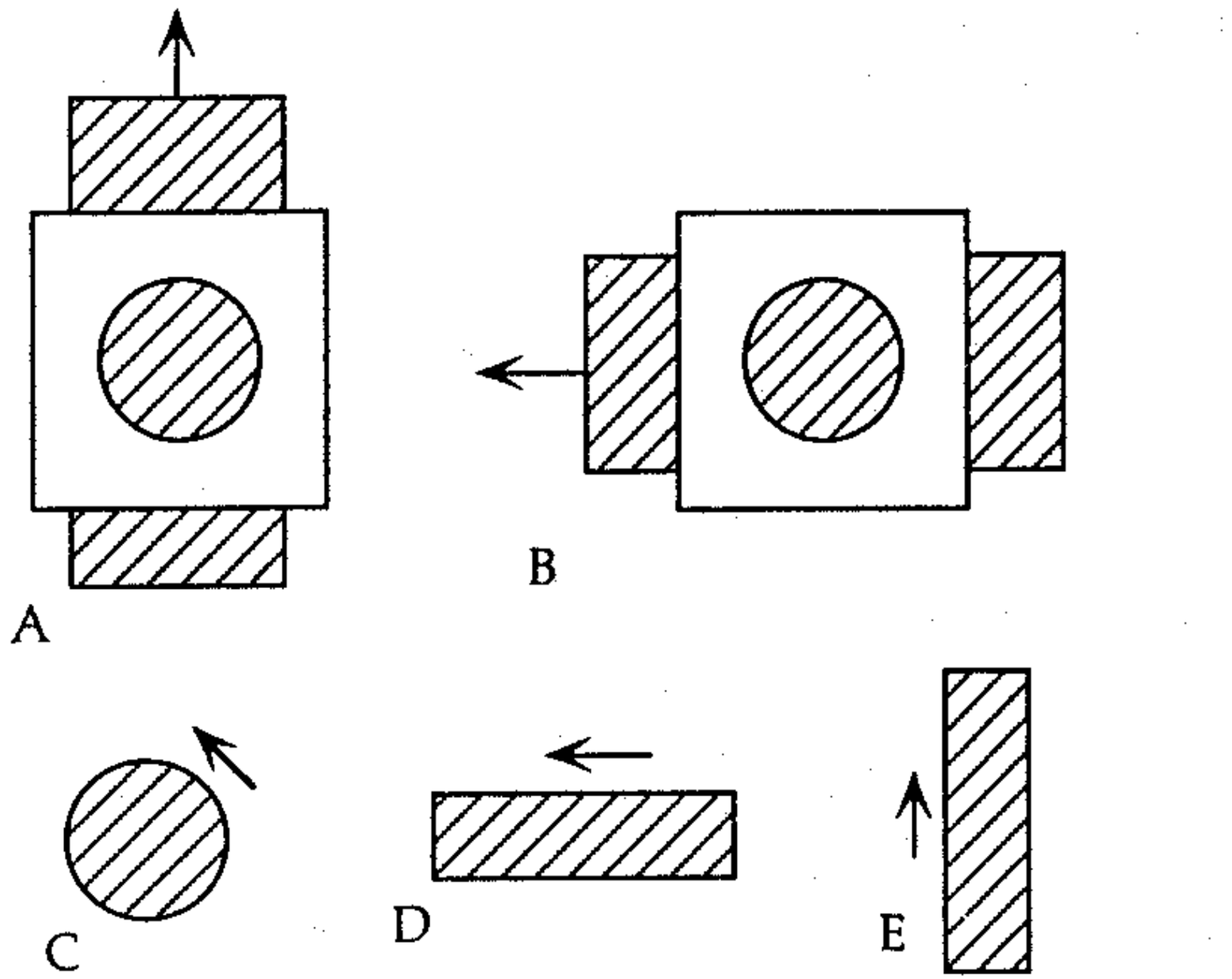
Texture segregation

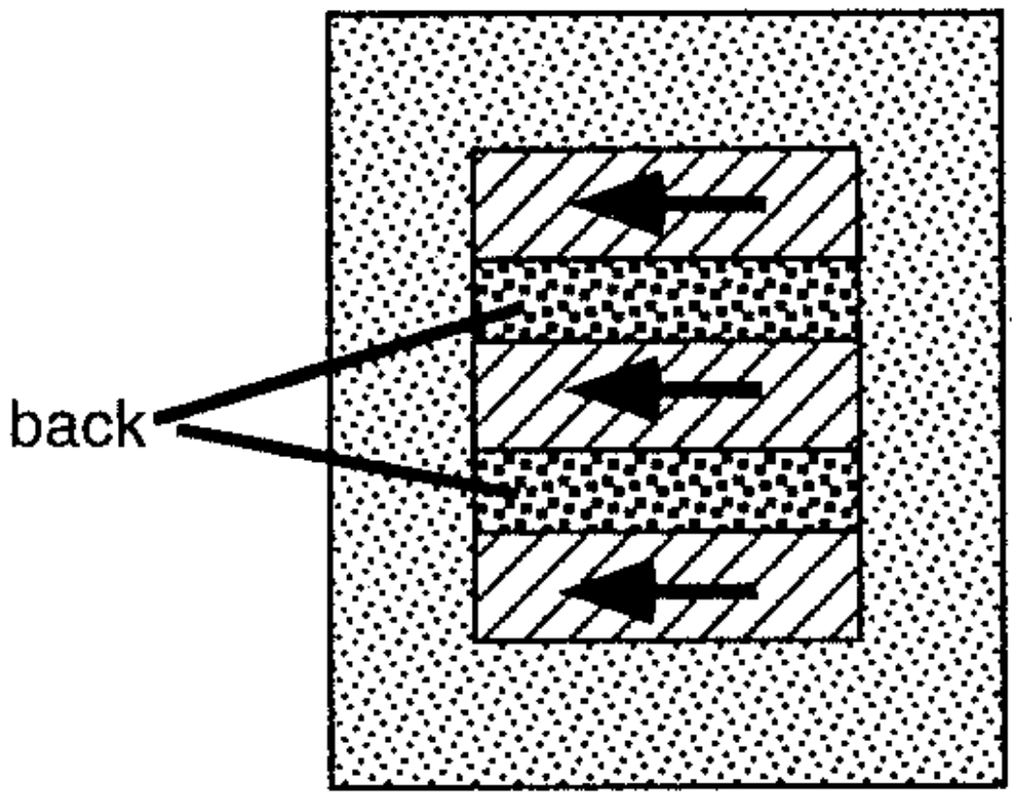



PERCEIVED
(A)
white L shape in front
(B)
white square in back
occluded by black square
(C)
white L shape in front
and back
X
U

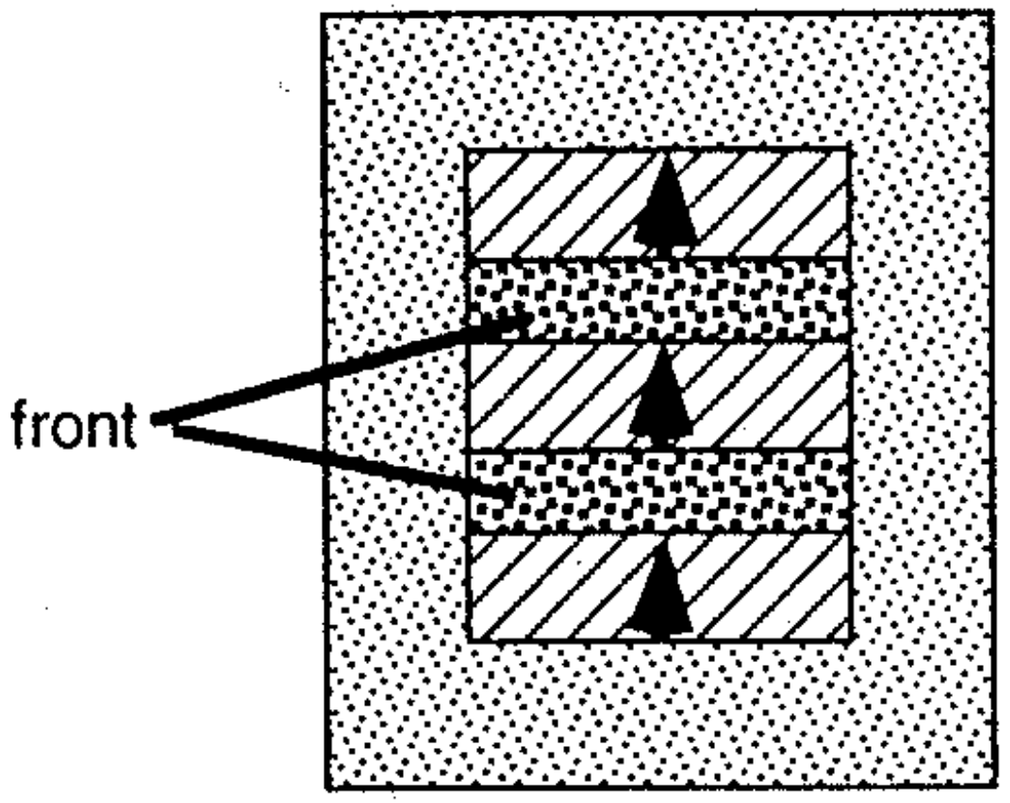

Percent Correct
100
90
80
70
60
50
BA
RM
SS
TW
ZH
Front
Back
Disparity= ±9 min

Motion: aperture problem





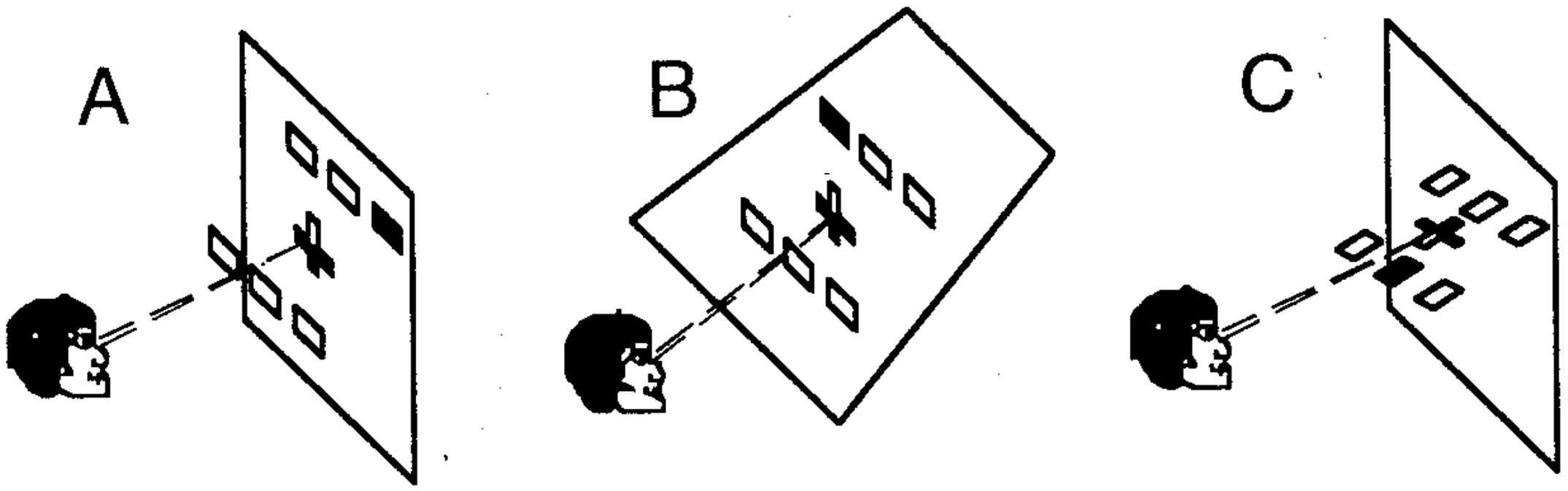
A



B

Attention spreads by surface assignment in 3D, not 2D

(Nakayama, He & Shimojo 1995)



Do oriented filters make it any easier to resolve figure-ground?

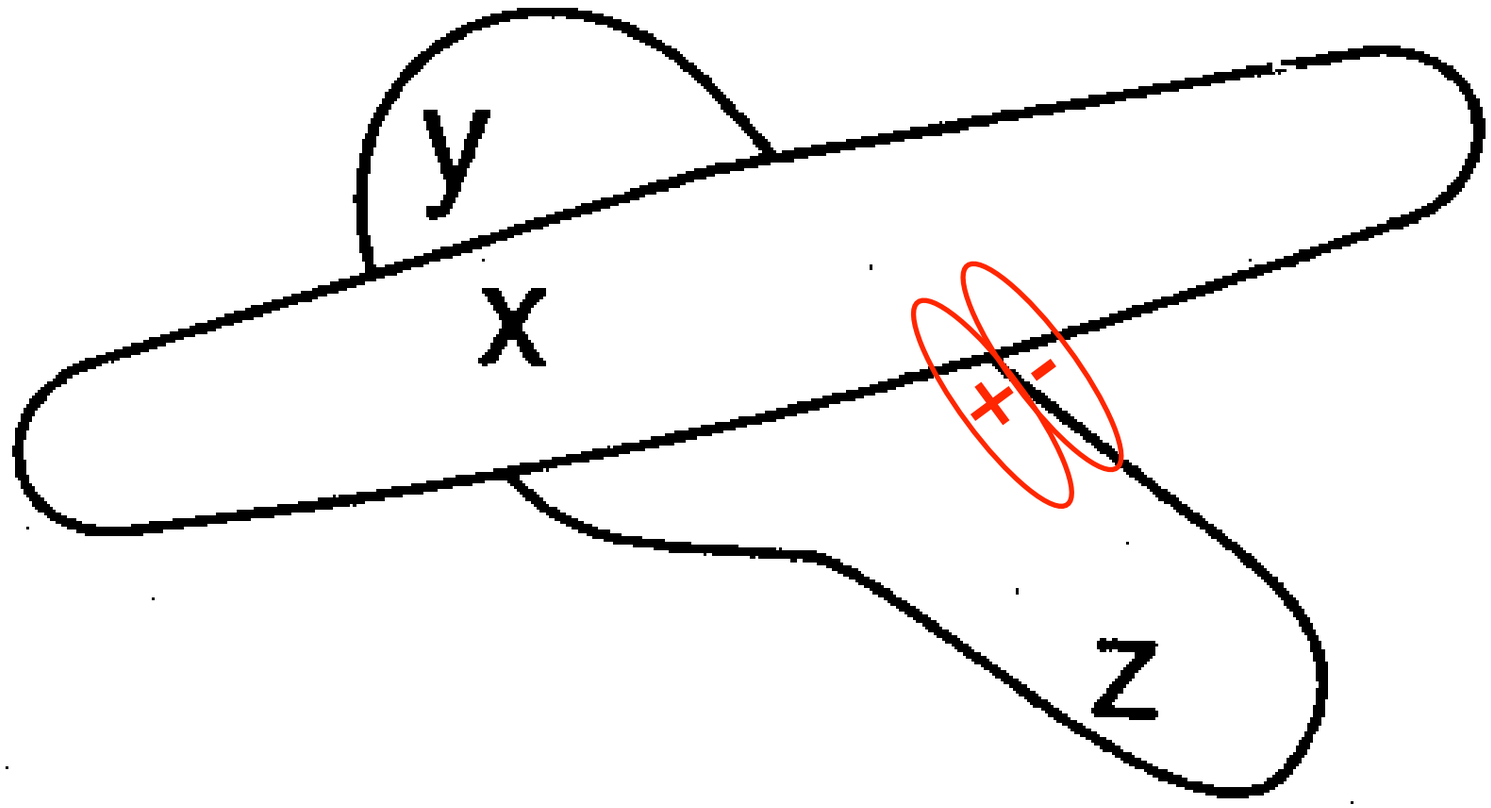
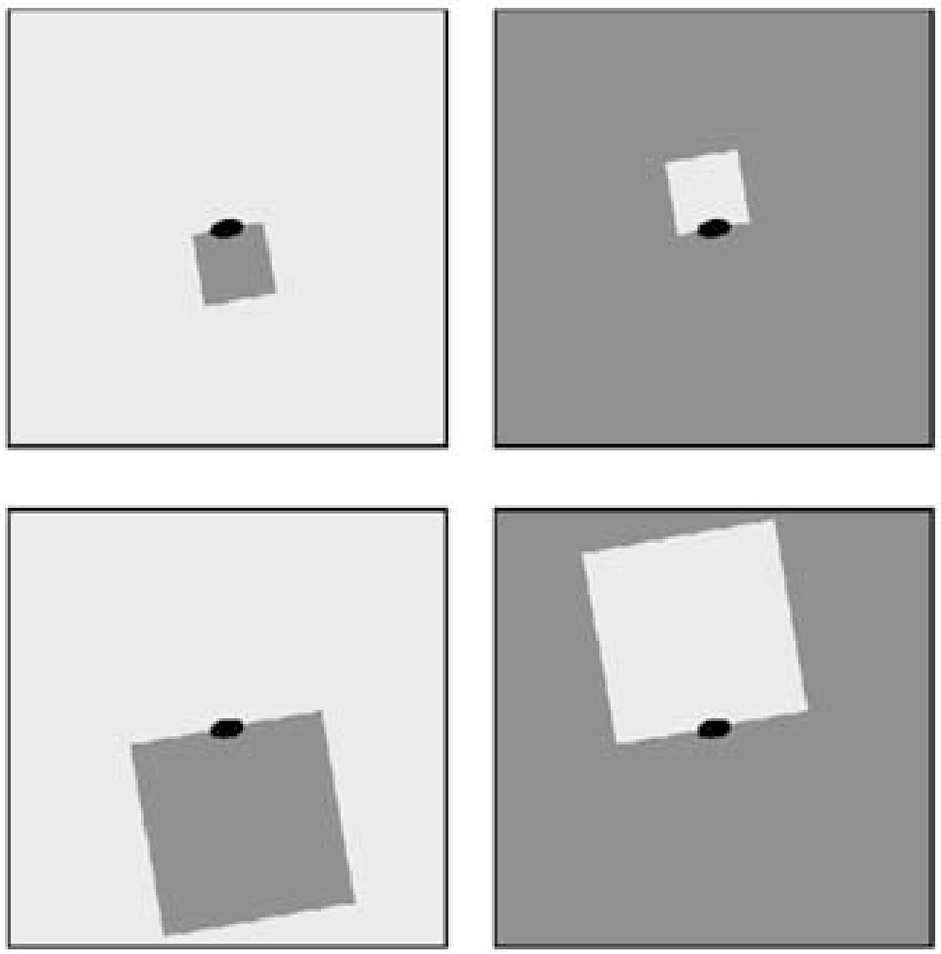
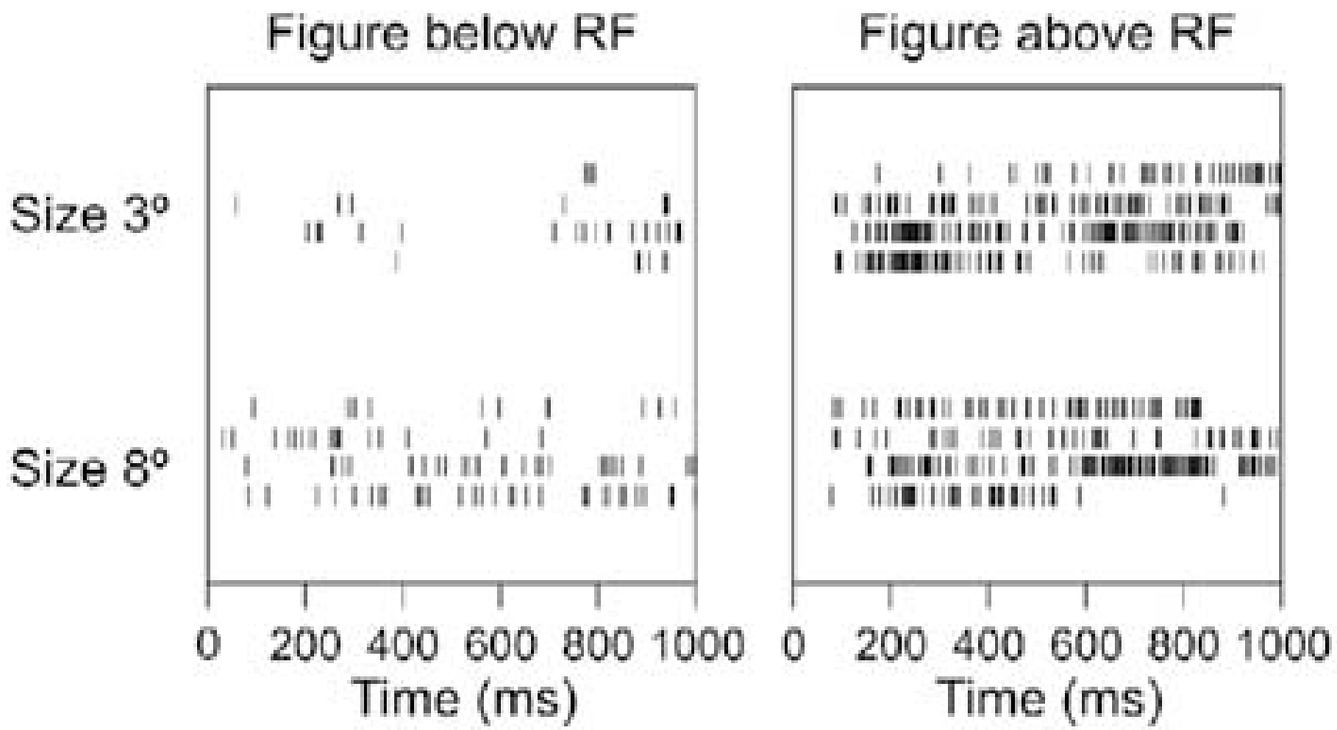


image segmentation ≠ figure-ground

Neurons in V2 (and even some in V1) code for border ownership as well as orientation

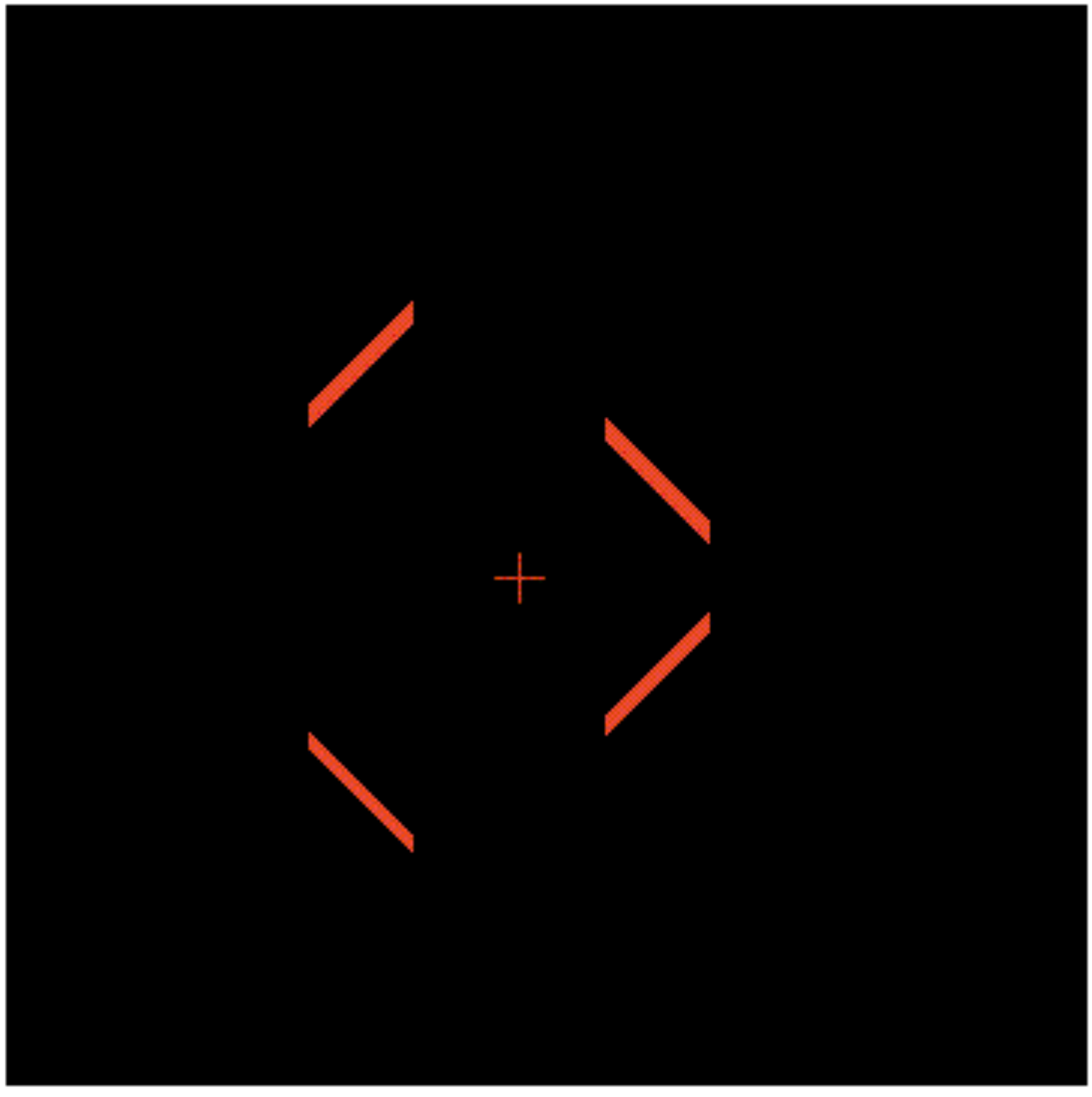
(Zhou, Friedman & von der Heydt, *J Neurosci, 20*: 6594–6611)





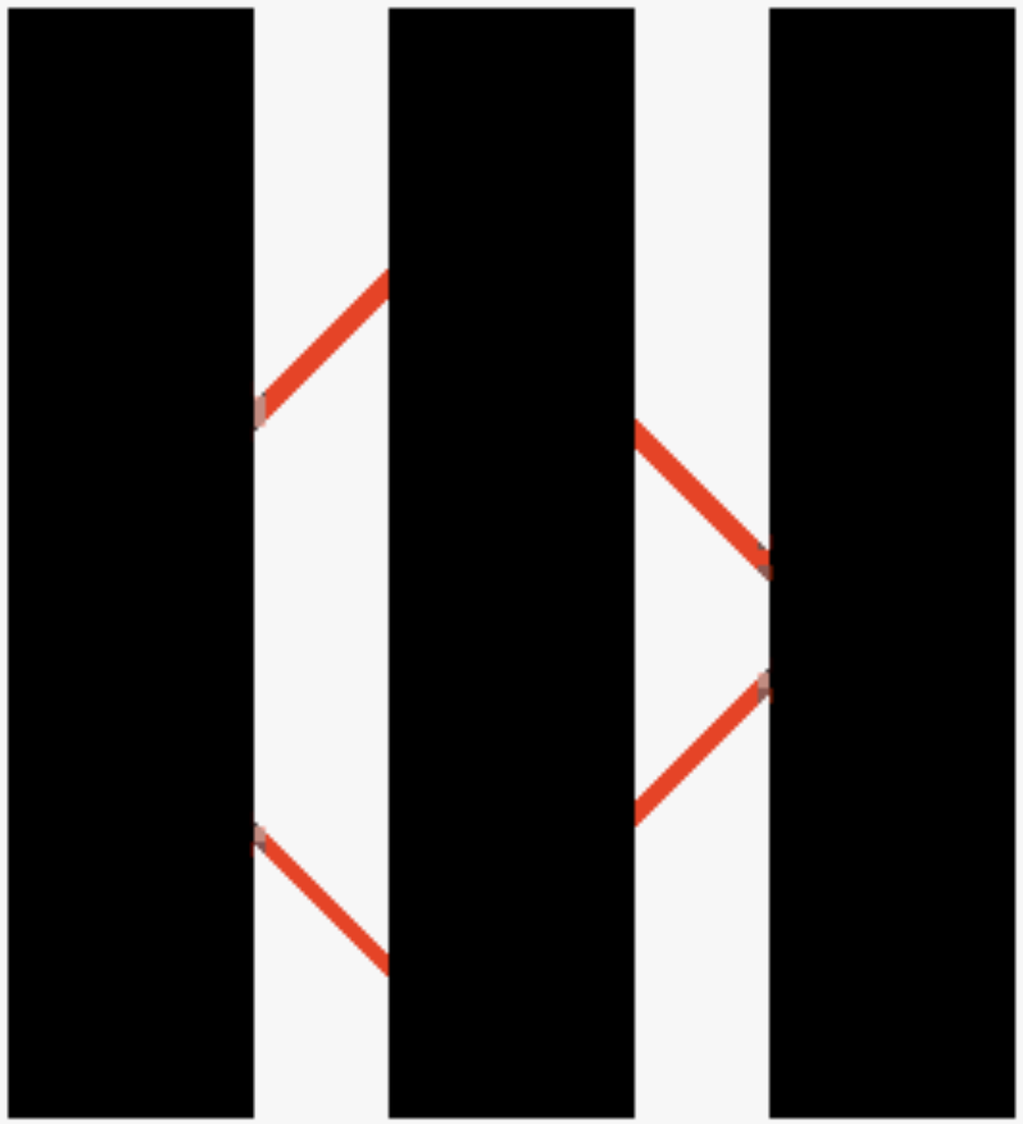
What do you see?

How do neurons in V1 encode this?

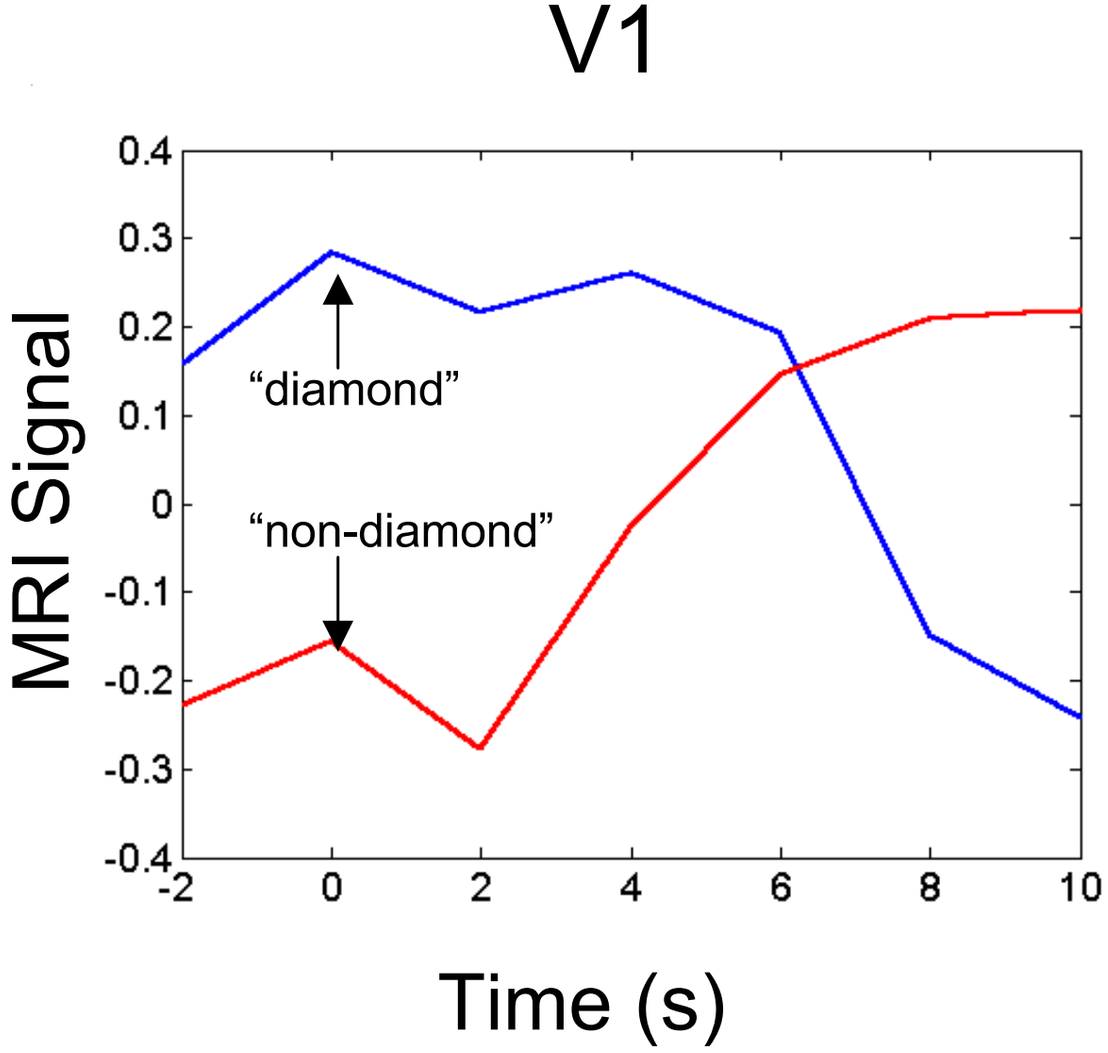


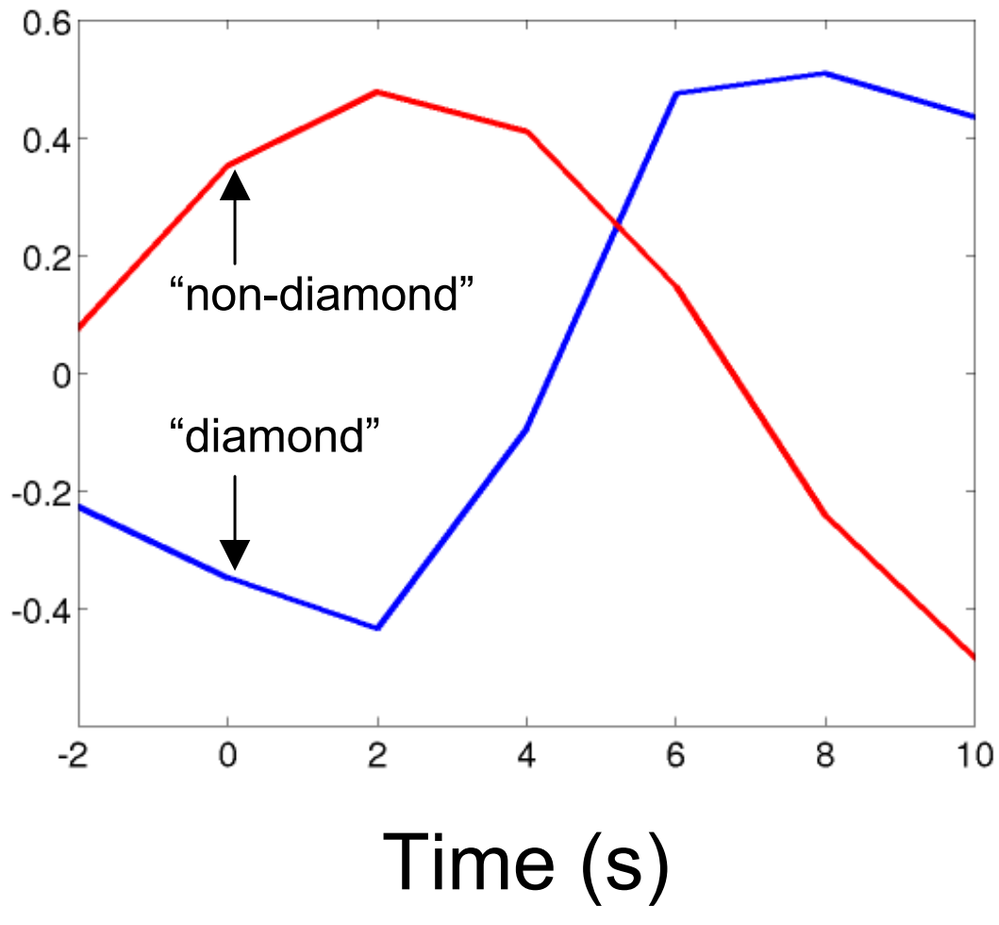
Murray, Kersten, Schrater, Olshausen, Woods, *PNAS* 2002.

(easy version)



BOLD signal in V1 and LOC





Open questions

- How do visual neurons respond to object borders vs. reflectance changes in natural images?

- How is border ownership computed? How do neurons encoding border ownership interact?

- Is amodal completion represented implicitly or explicitly?