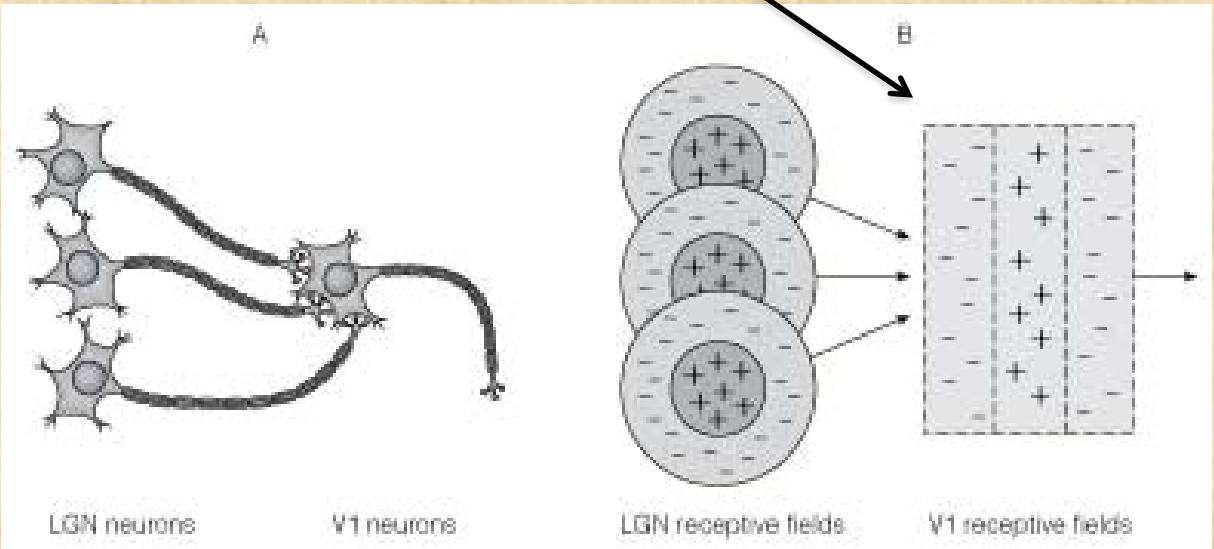
Perception, Part 1
Gleitman *et al*. (2011), Chapter 5

Mike D'Zmura
Department of Cognitive Sciences, UCI

Psych 9A / Psy Beh 11A
February 25, 2014

Processing of Form Information

Electrophysiology reveals many types of cell, including
Simple Cells in primary visual cortex (V1)



Simple cells are orientation selective. They

-combine inputs from several neighboring center-surround cells

-are sensitive to position of bar in receptive field

-are *linear* in their response to light modulations

At each direction in the visual field, there are neurons in V1 of many sizes and of all *orientation selectivities...*

Visual image change is analyzed according to both scale and orientation.

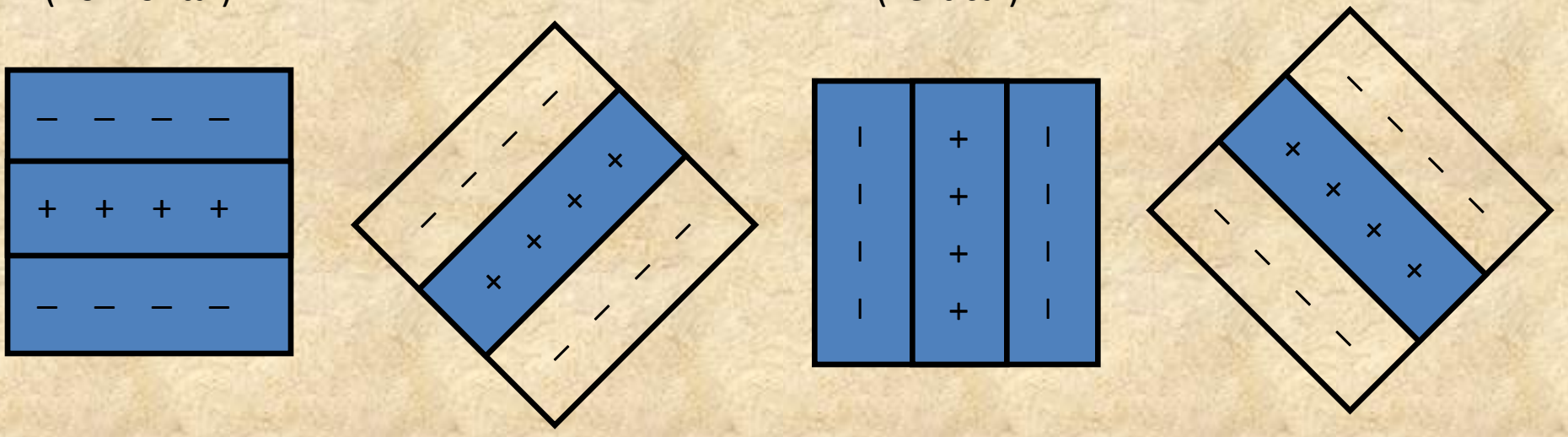
Bar detectors of varying orientation selectivity:

0 deg (horizontal)

45 deg

90 deg (vertical)

135 deg



an image:

the image filtered to emphasize energy at different orientations:

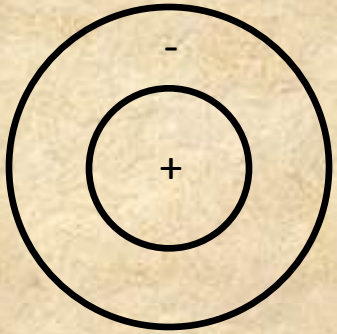
0 deg (H)

45 deg

90 deg (V)

135 deg

Actual receptive fields do not have
"cookie-cutter" shapes



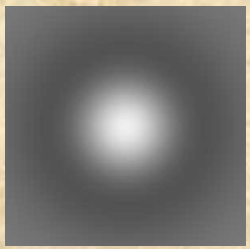
Rather, receptive fields typically have smooth profiles resembling normal (Gaussian) functions within which one finds excitatory and inhibitory zones. For example:

excitatory center

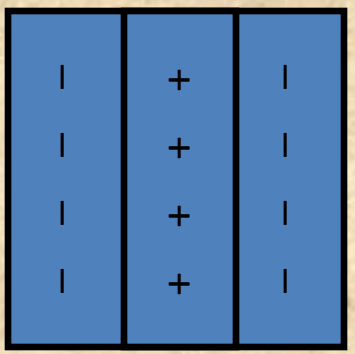
inhibitory surround

Difference-of-Gaussians
receptive field profile

Convention for interpreting 2D image
brighter than gray background: excitation
darker than gray background: inhibition

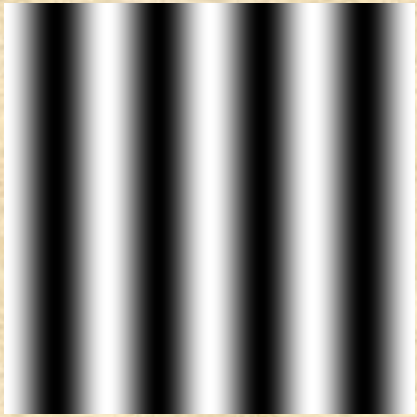


Actual receptive fields do not have "cookie-cutter" shapes:



A ***Gabor function*** is a product of a Gaussian and a sinusoid:

x



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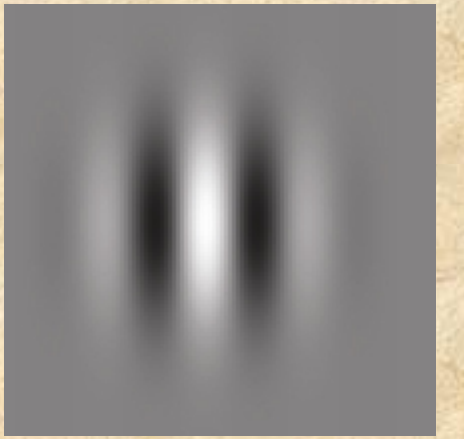
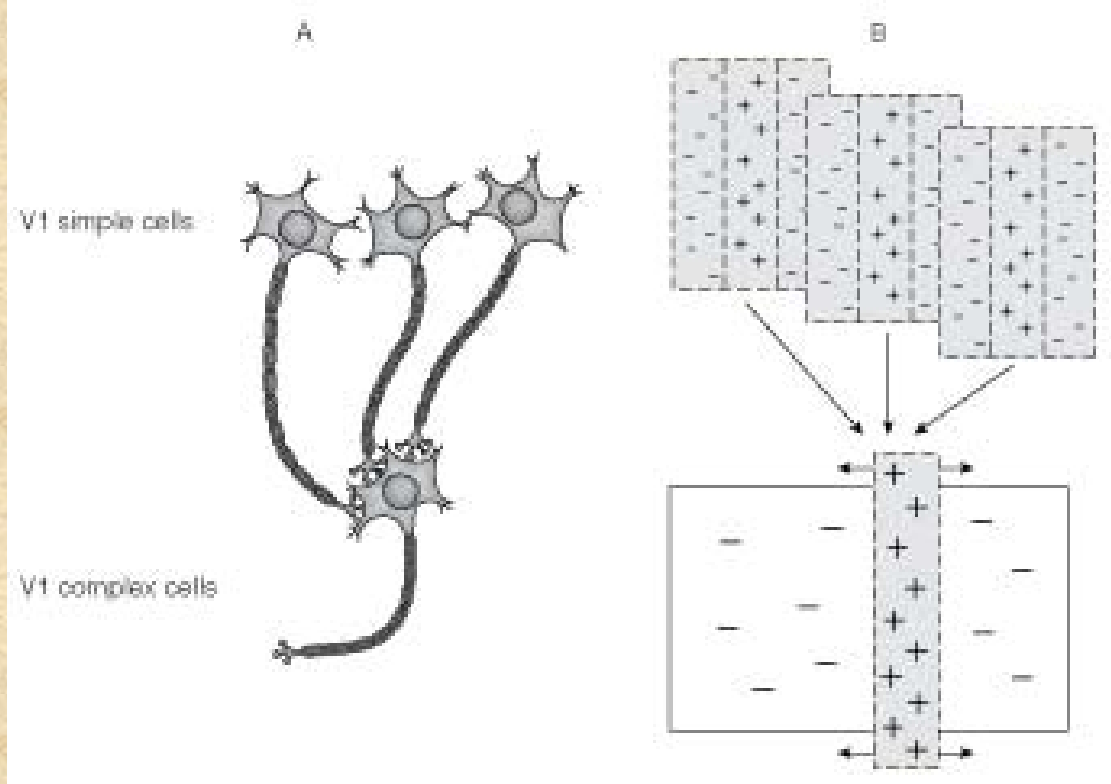


The receptive field profiles of orientationally-selective simple cells in V1 are often fit well by Gabor functions.

Complex cells



Complex cells are orientation selective. They

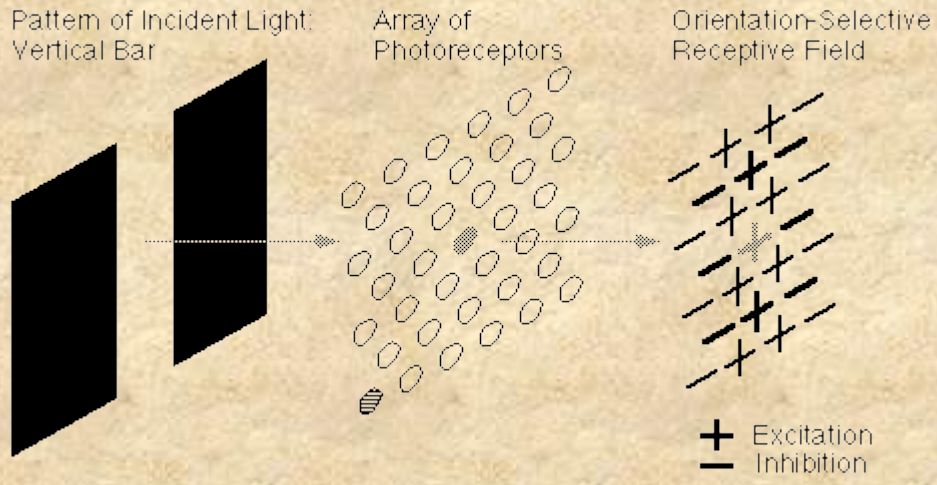
-combine inputs from several neighboring simple cells

-are *insensitive* to the position of a bar in the receptive field

-respond *nonlinearly* to light level modulations

Pattern Recognition

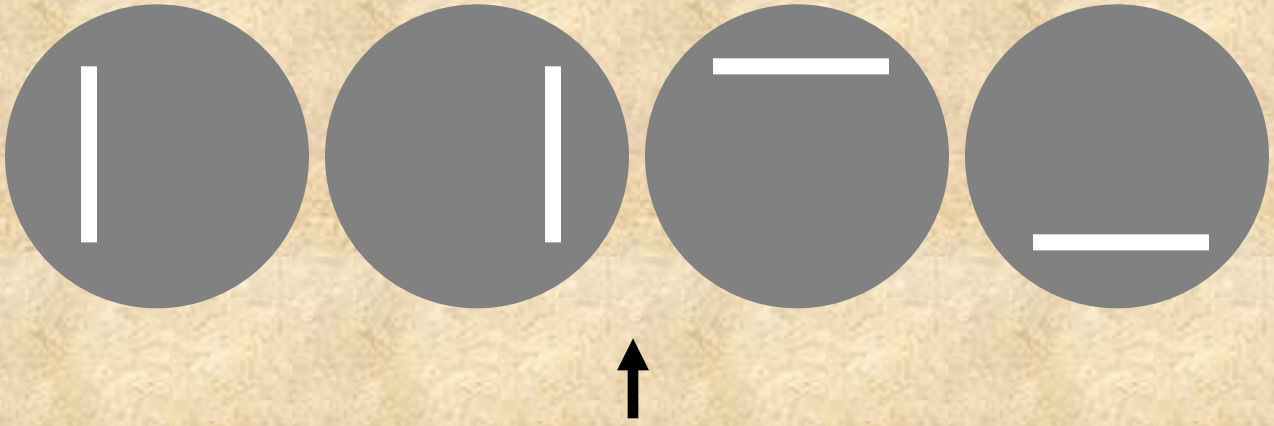
Feature Net – a model of pattern recognition involving a network of detectors with feature detectors as initial processing elements



For example, how might we use orientation-selective bar detectors (a variety of feature detector) to detect a square?

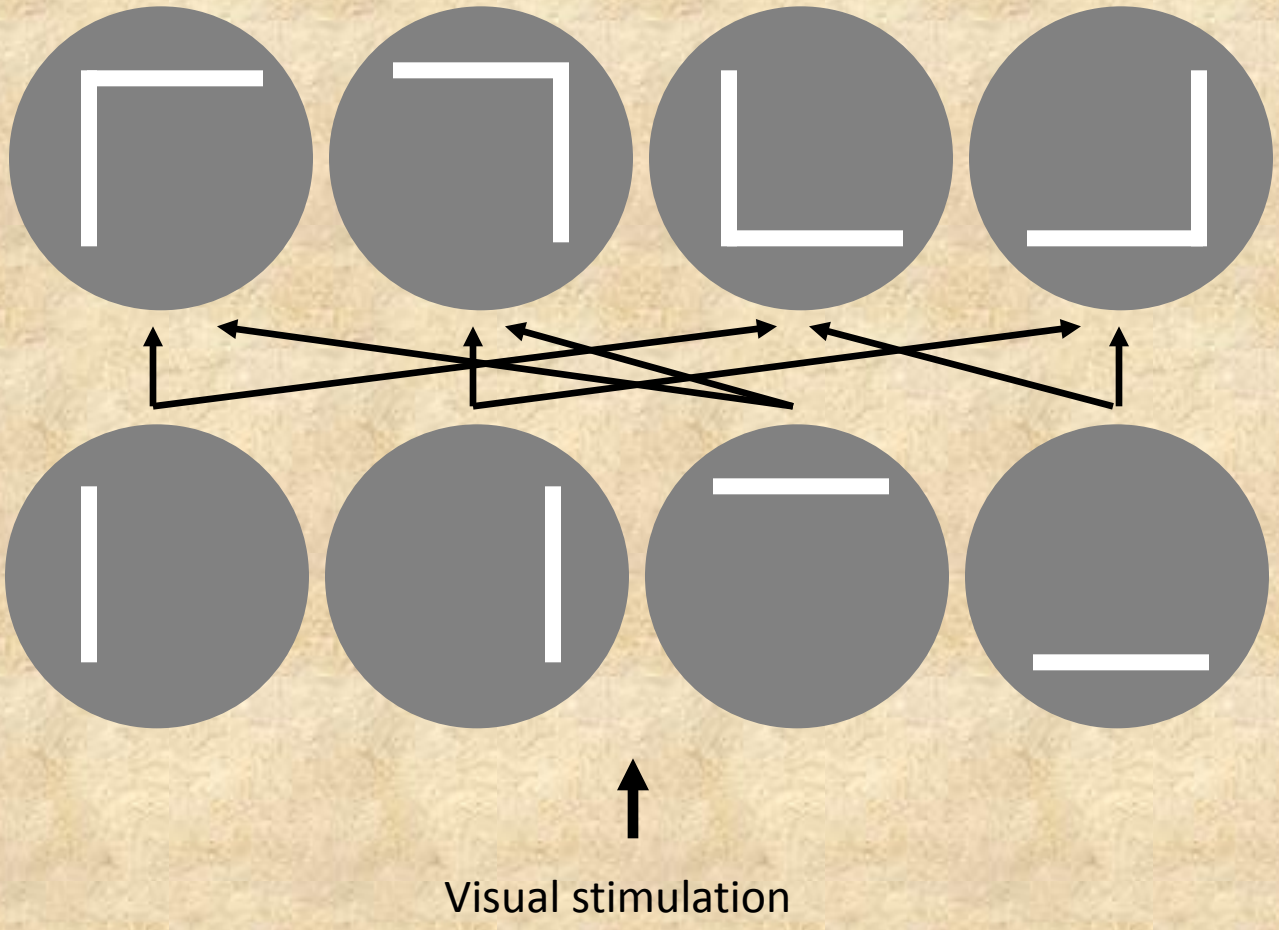
Feature Nets

Bar detectors



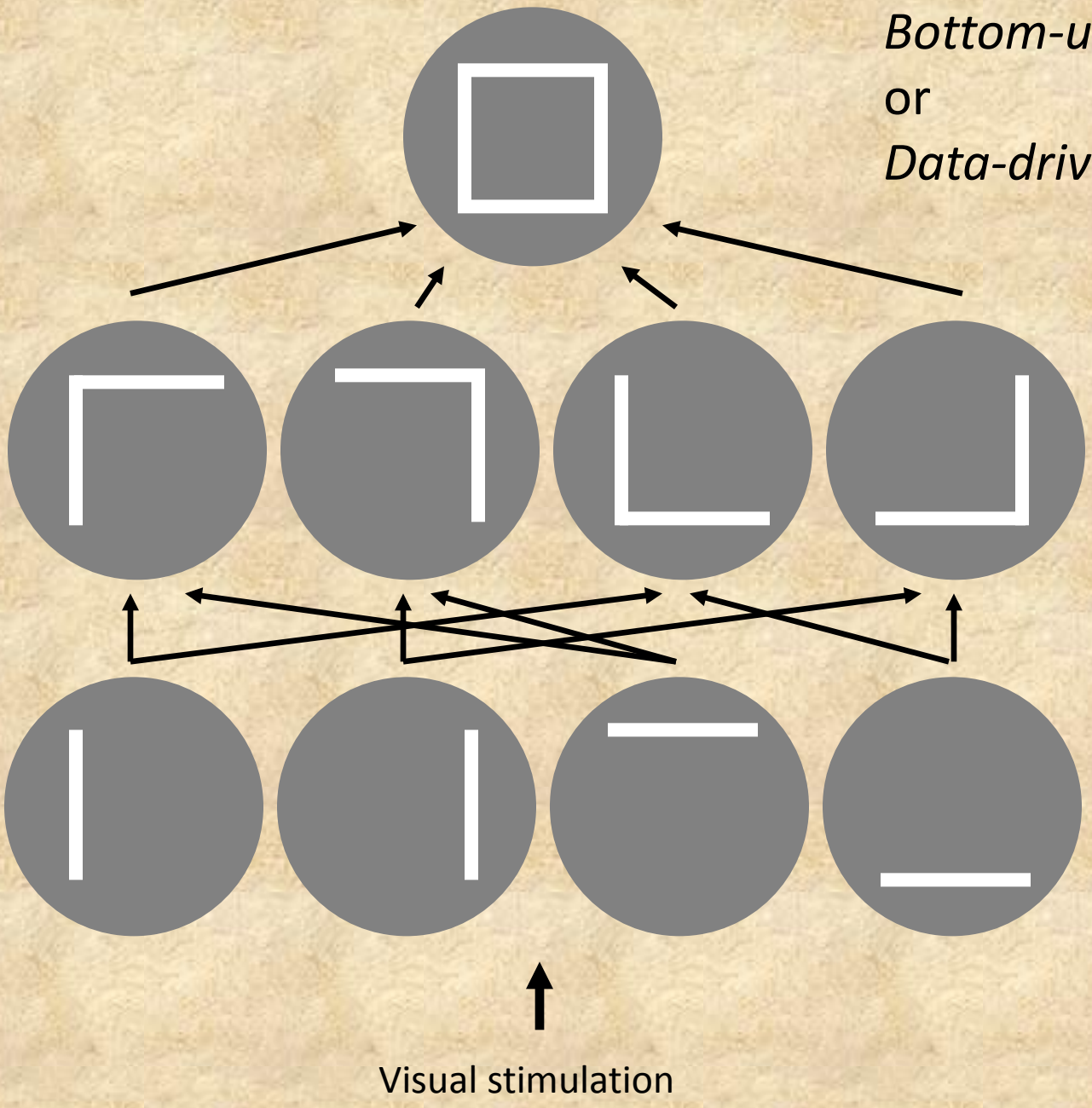
Visual stimulation

Feature Nets



Feature Nets

Bottom-up
or
Data-driven

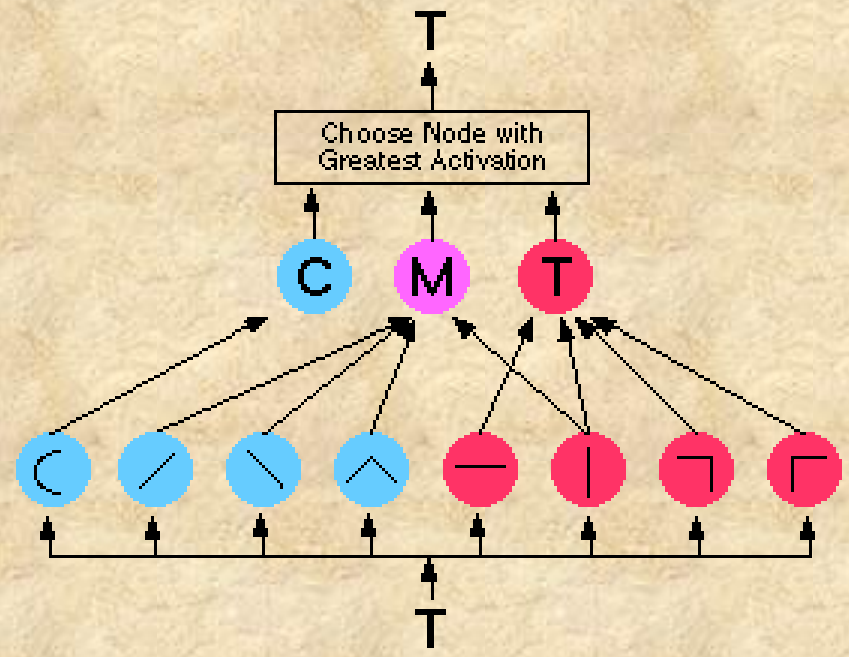


Analysis by Feature Detectors

as illustrated by the

"Bottom-Up" portion of the Pandemonium Model by Selfridge

Task: try to recognize a written letter using visual information (e.g., pattern of black/white on a page)



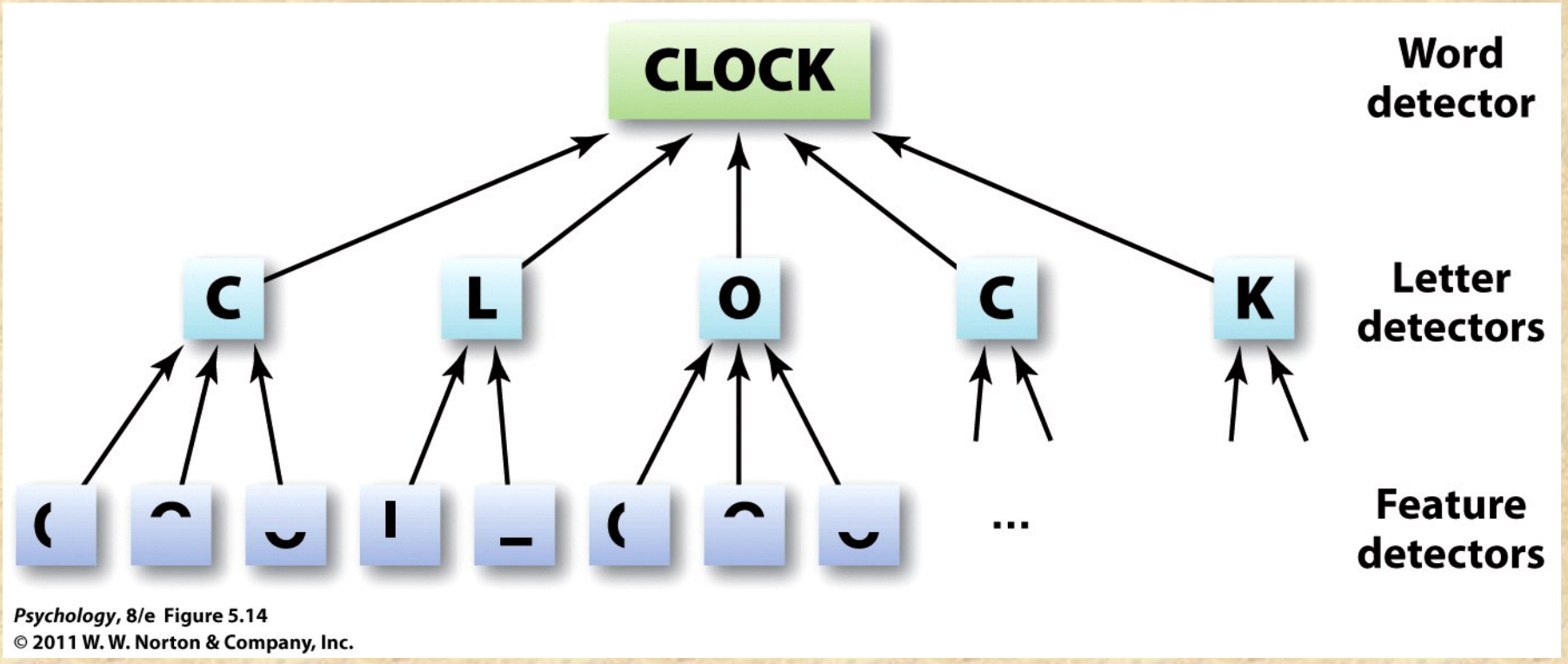
decision-maker

letter detectors

feature detectors

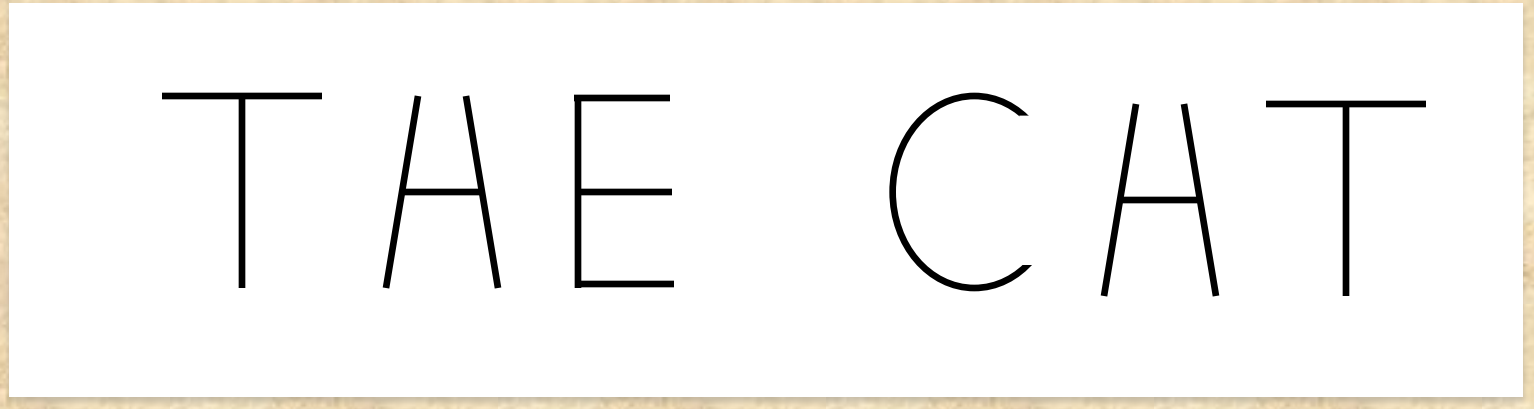
Optical Character Recognition (OCR)

Bottom-up processing in visual word recognition



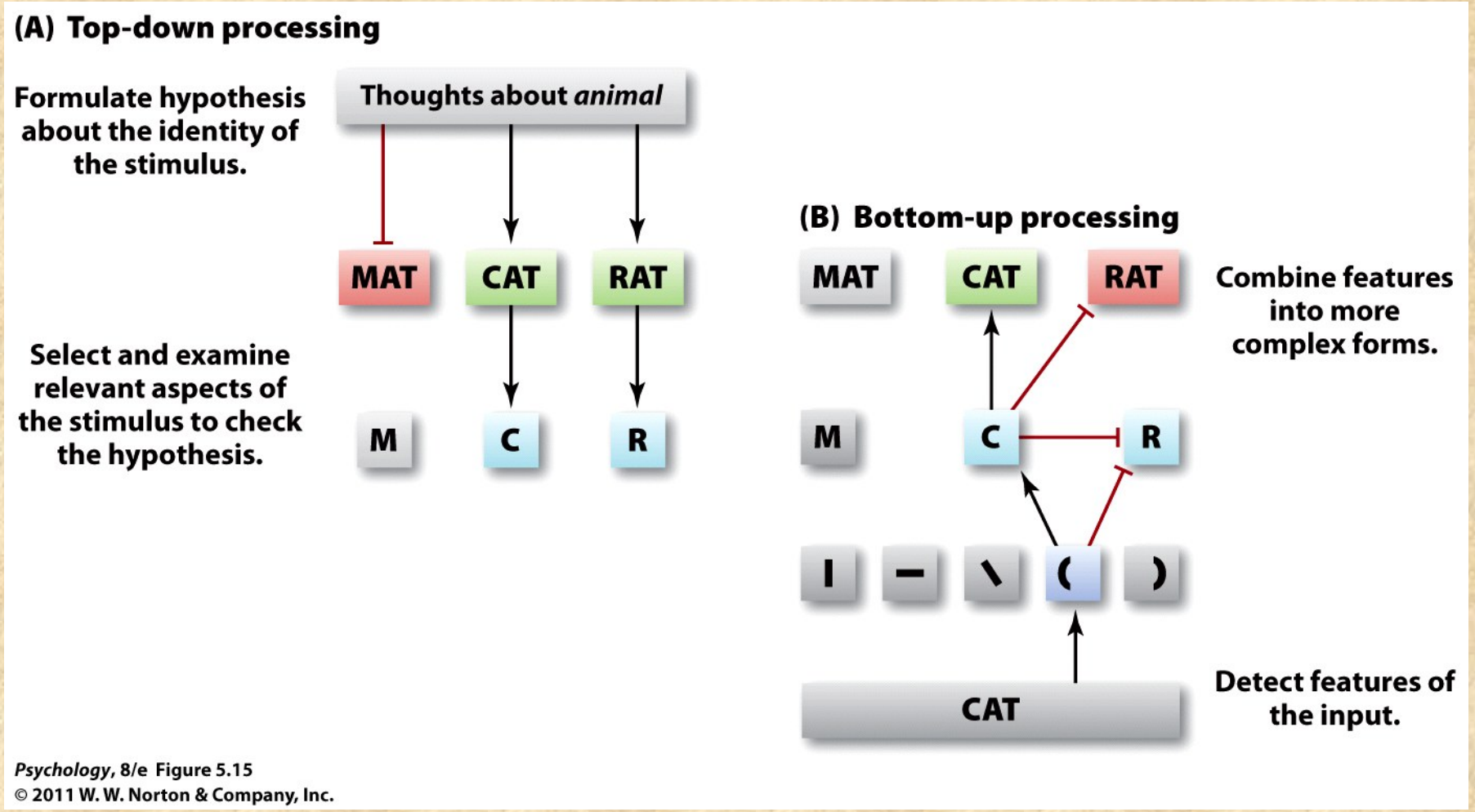
Psychology, 8/e Figure 5.14

Top-down processing



Top-down processing

context affects what is perceived



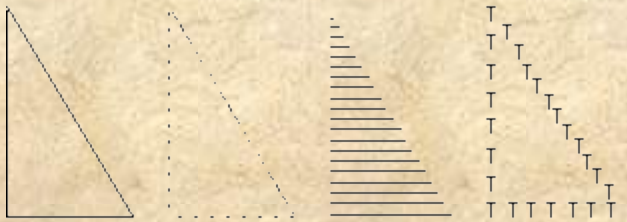
Psychology, 8/e Figure 5.15

Form perception

Basic idea behind the Gestalt approach:

sensory *features* are grouped in a way which allows more global shape/form or *figural* properties to emerge

For instance, the triangles below all have the same shape, even though the sensory feature constituents differ



Transposition

Feature Extraction

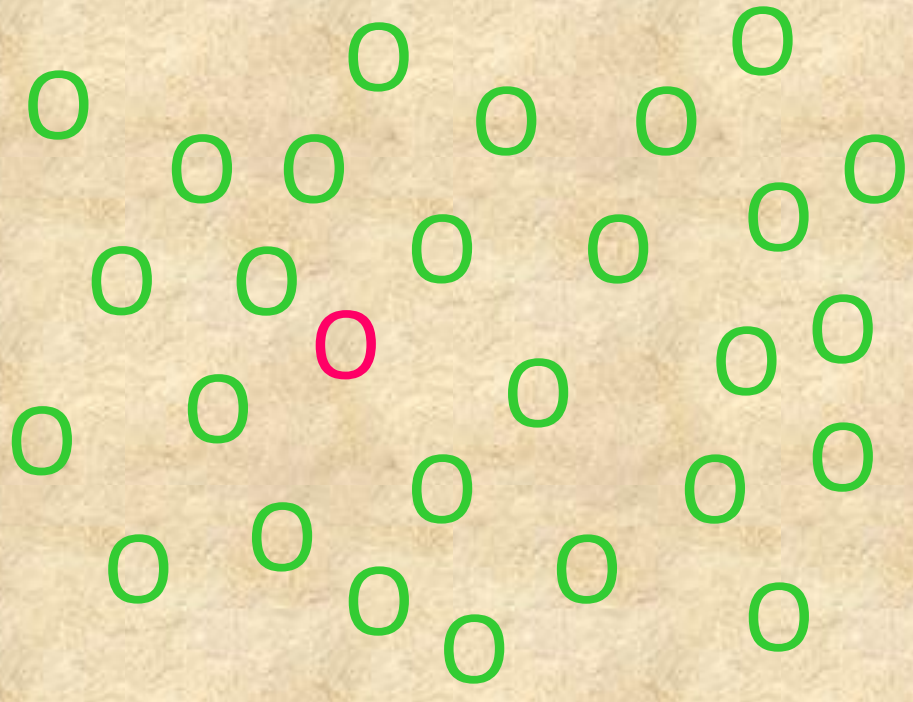
What are the basic *features* used by the visual system?

The results of *visual search* experiments (Anne Treisman) show how a *target* must differ from *distractors* in order to be detected easily, in a spatially parallel fashion.

O target

Visual search: evidence for visual features

Some searches are very easy. Indeed, it appears that certain items (like the red O) can draw one's visual attention. Such a target is said to *pop out.* In this case, attention is directed by the stimulus (bottom-up).

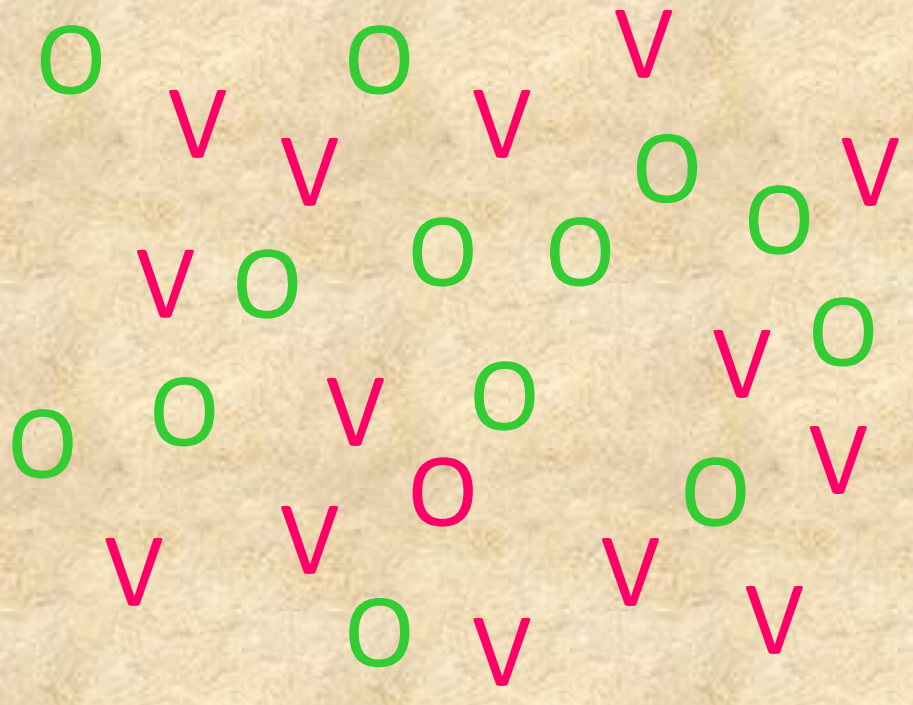


Visual search

Here's another example of pop out – bottom-up direction of visual attention by the stimulus

Visual search

When a single feature does not suffice to distinguish target from distractors, search is usually more difficult. Search times are longer and search gets tougher the more items there are being displayed.

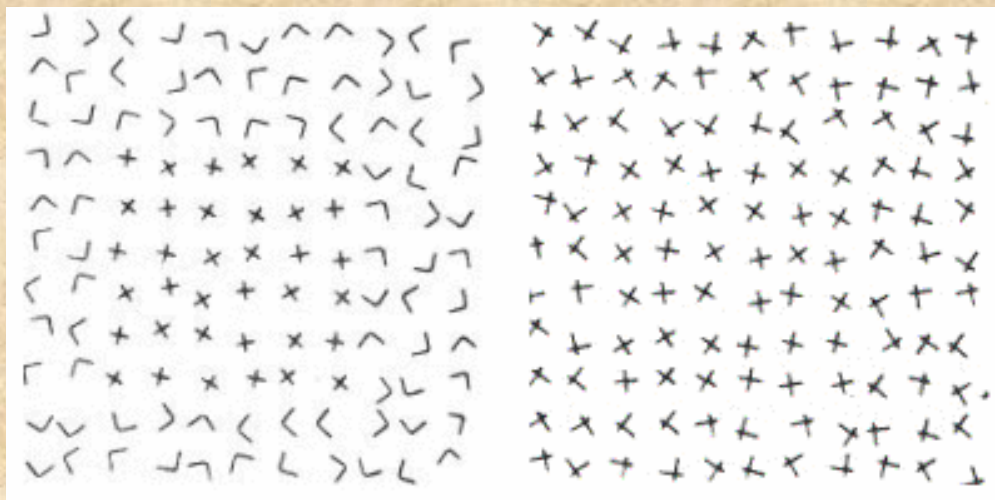


In such cases, people tend to search through the items one-by-one, looking for the red O. People direct their visual attention in such cases in a top-down way.

Texture segregation: evidence for visual features

What are the basic *features* used by the visual system?

The results of *texture segregation* experiments (Bela Julesz) show how two or more areas must differ in texture in order for the boundary to be detected quickly and easily.



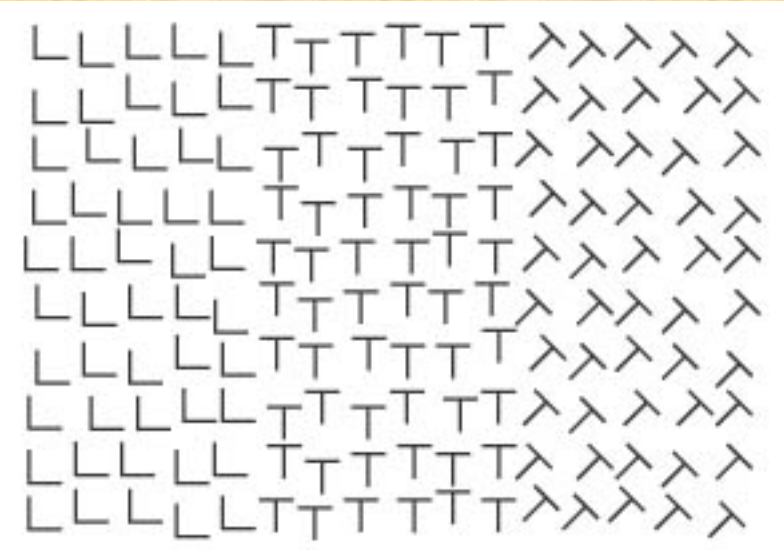
from http://civs.stat.ucla.edu/Texture/Human/human_vision.htm

Texture Segregation

T-junctions absent

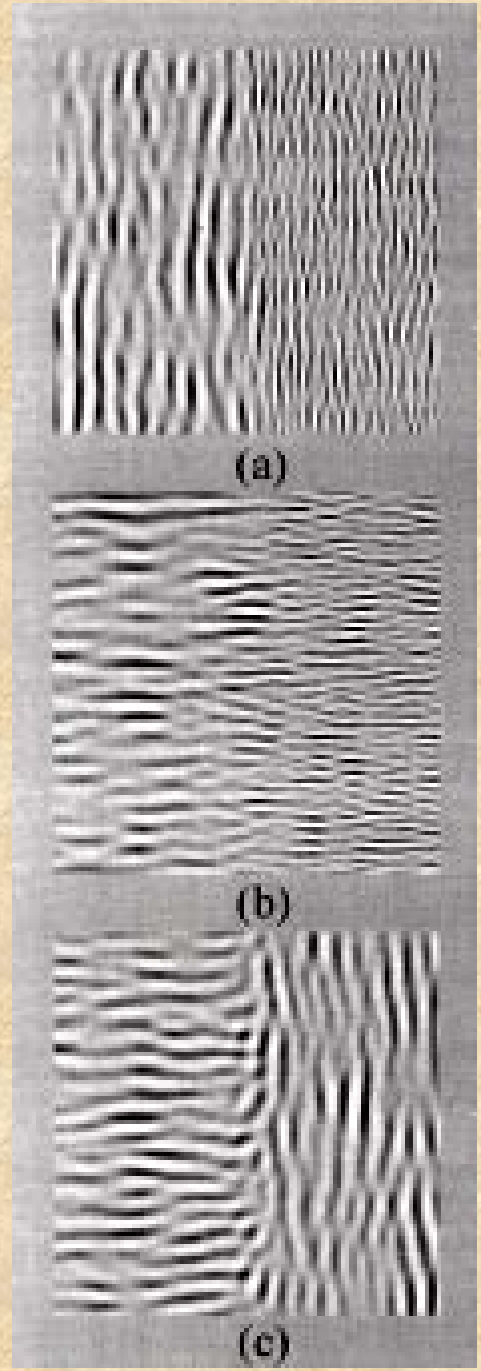
T-junctions present (0 deg)

T-junctions present (45 deg)



More basic *features*
used by the visual system...

The figure at right suggests that
stripe size (a,b)
and
orientation (tilt - c)
differences can serve as features.



from Landy, M.S. & Kojima, H. (2001)
JOSA A 18(9) 2307-2320.

What are the basic *features* used by the visual system?

Methods to determine:
Visual Search
Texture Segmentation
Neuron Sensitivities

Features identified:
Brightness, Color, Orientation, Spatial Frequency / Scale / Size, Length, Curvature, Motion, etc.

Features may be *grouped* to produce *figures* or *Gestalts* with *emergent properties*

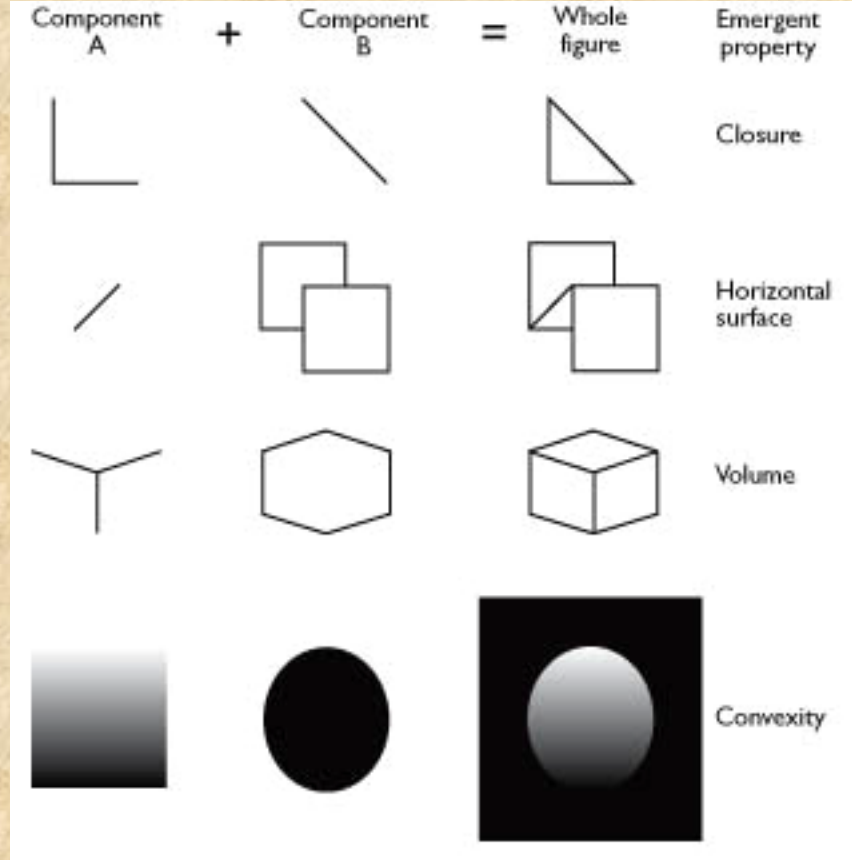
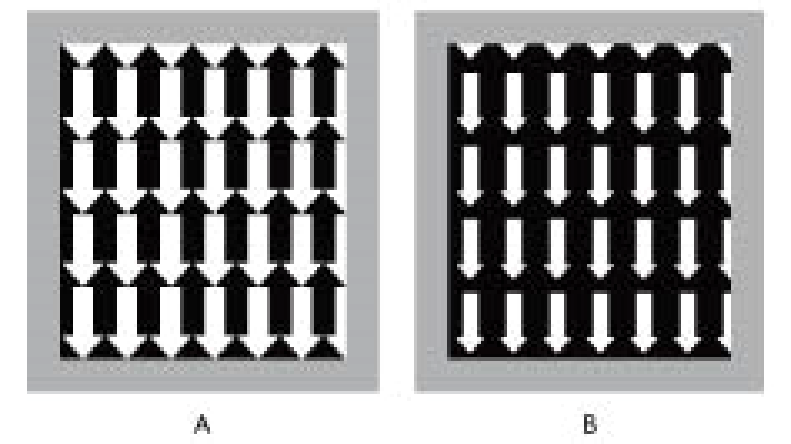


Figure And Ground

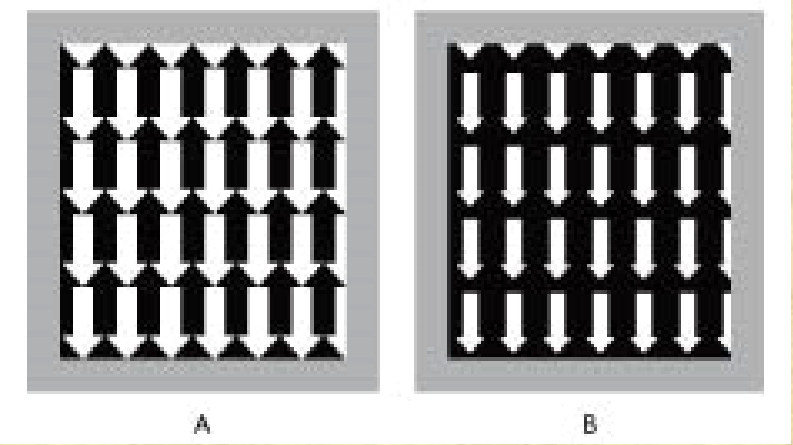
a reversible figure

a reversible figure

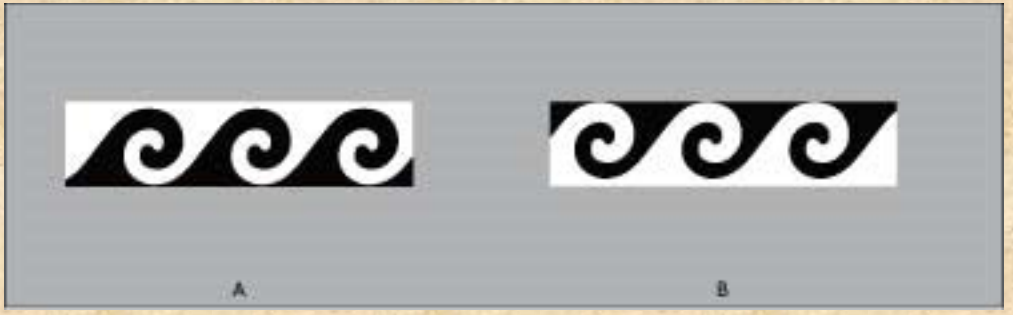


more reversible figures

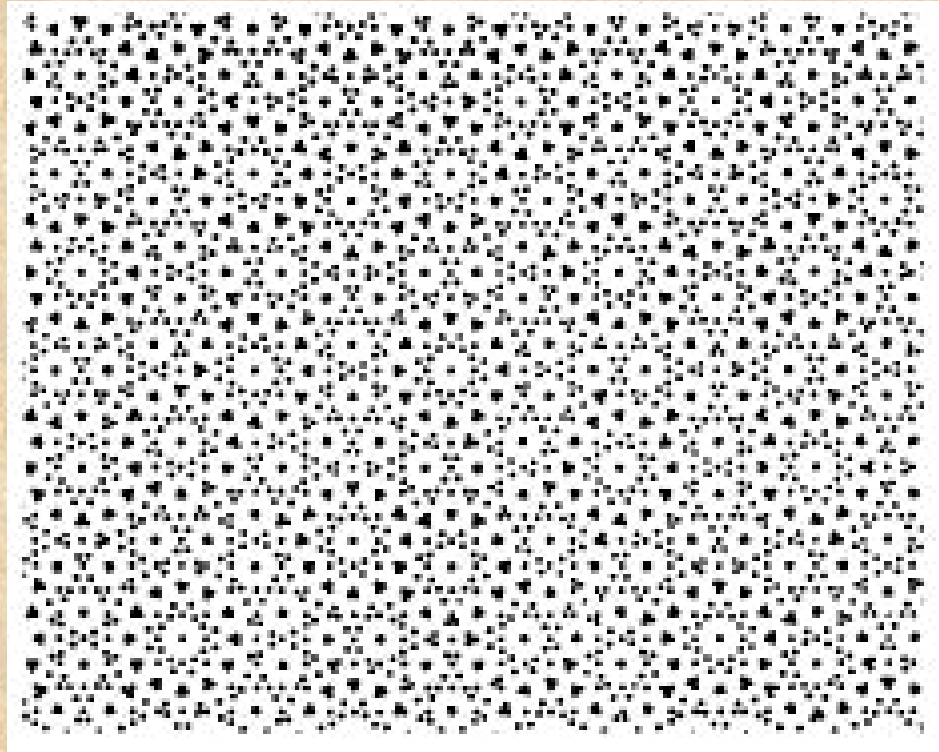
a reversible figure



more reversible figures



reversible figures with a bias (gravity?)



A Glass pattern. The visual system works hard to see figures in visual images.

Gestalt Laws of Perceptual Organization

Max Wertheimer

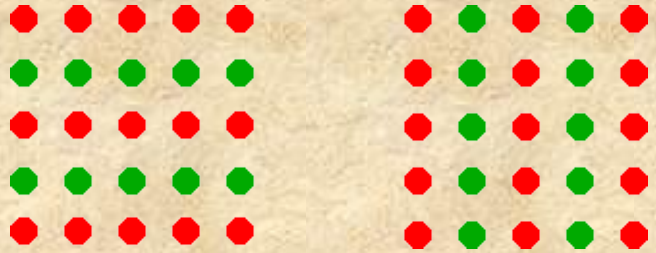
proximity

things close to one another get grouped together

Gestalt Laws of Perceptual Organization

proximity

similarity

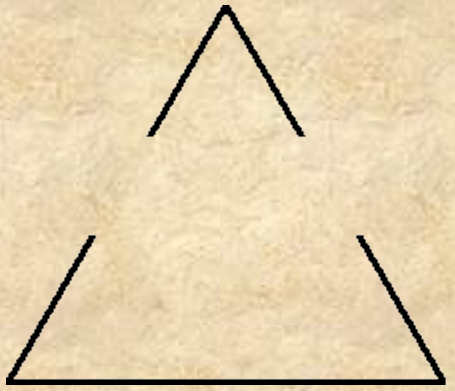


things similar to one another get grouped together

Gestalt Laws of Perceptual Organization

proximity
similarity

closure



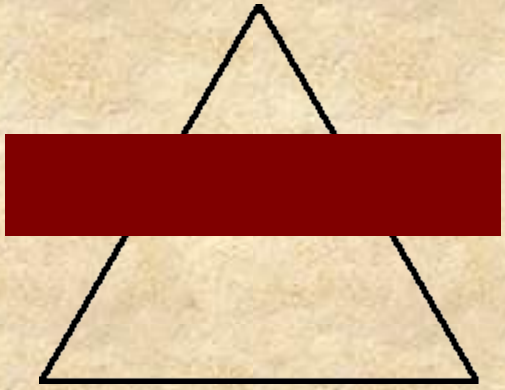
edge segments will be joined if the joining results in a closed figure

1. provided the segments line up
2. if there is a reasonable interpretation in terms of occlusion

Gestalt Laws of Perceptual Organization

proximity
similarity

closure



occlusion
or
interposition

Gestalt Laws of Perceptual Organization

proximity
similarity
closure

good continuation

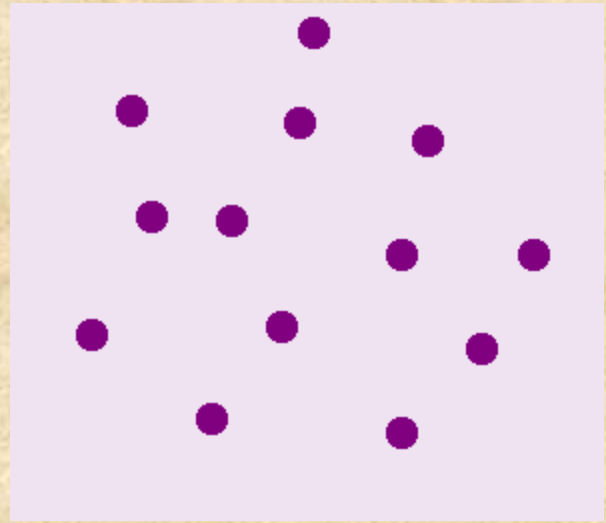
continue an edge in a way that minimizes change in direction

No Yes

Gestalt Laws of Perceptual Organization

proximity
similarity
closure
good continuation

common fate



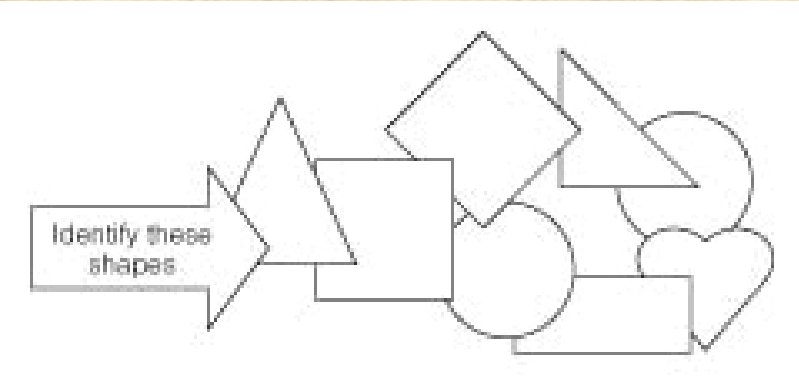
things that move together get grouped together

Gestalt Laws of Perceptual Organization

proximity
similarity
closure
good continuation
common fate

Law of Prägnanz: organization of visual array into perceived objects will be as "good" as prevailing conditions allow

What is good? 1. regularity 2. simplicity 3.symmetry

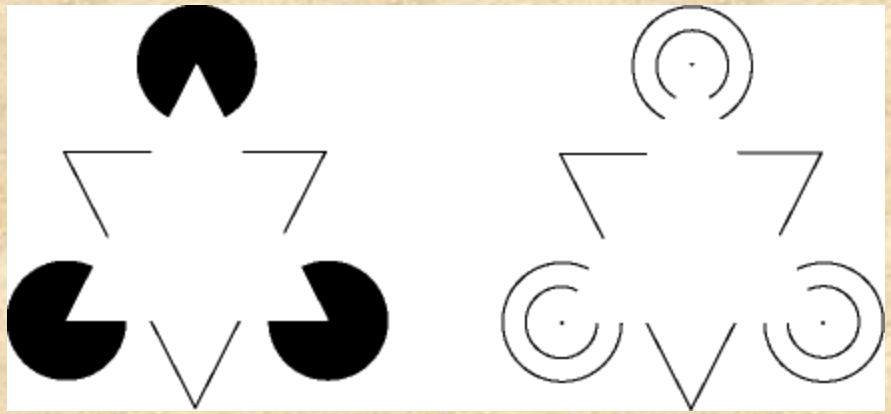


the simplest interpretation of this figure uses closure...

Gestalt Laws of Perceptual Organization

Intrinsic contours – belonging to an object or figure
Extrinsic contours – a consequence of interposition (an object in front)

These contours (especially extrinsic contours) may be *filled in*



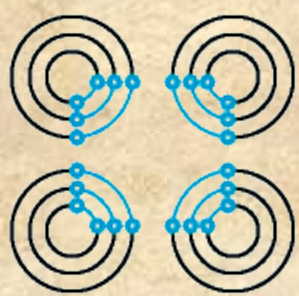
Kanizsa Triangles
with *subjective contours*
seen for the "white" triangles
(base at bottom)

Gestalt Laws of Perceptual Organization

Contours may be *filled in* in other ways: neon color spreading

Neon Disk

Worm

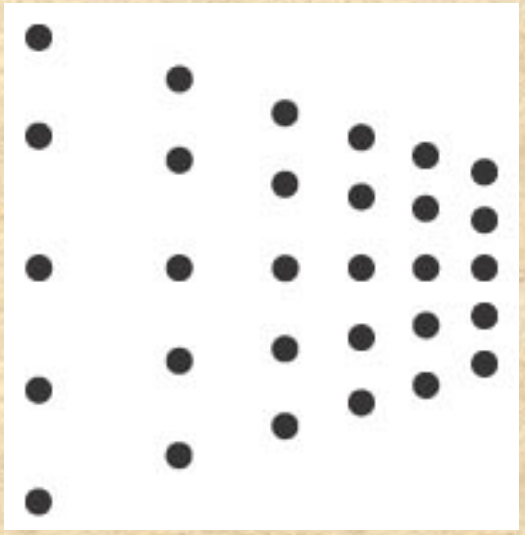


Neon Square

from Don Hoffman,
http://www.cogsci.uci.edu/~ddhoff/

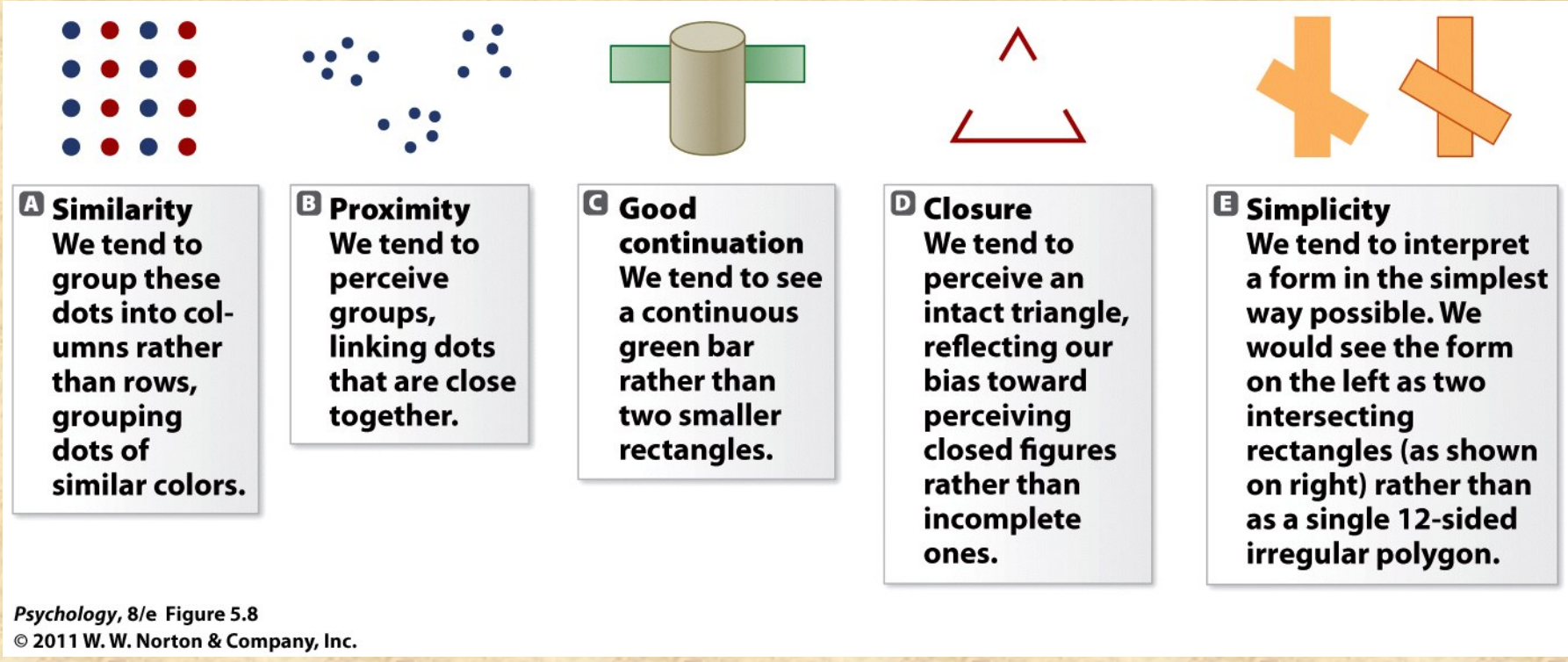
Gestalt Laws of Perceptual Organization

The operation of the visual grouping principles may be modified by a number of other factors (e.g., perceived depth)



proximity
vs.
perceived depth

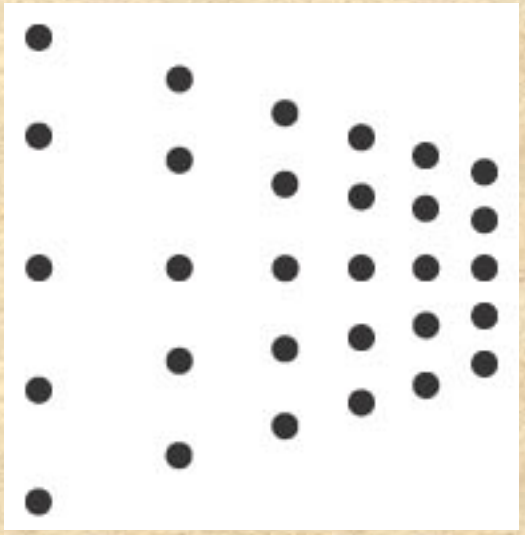
Gestalt Laws of Perceptual Organization
As per the textbook



Psychology, 8/e Figure 5.8

Gestalt Laws of Perceptual Organization

The operation of the visual grouping principles may be modified by a number of other factors (e.g., perceived depth)



proximity
vs.
perceived depth