Object vision (Chapter 4)

Lecture 8

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Sensation & Perception
(PSY 345 / NEU 325)
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Outline for today:

Chap 3:

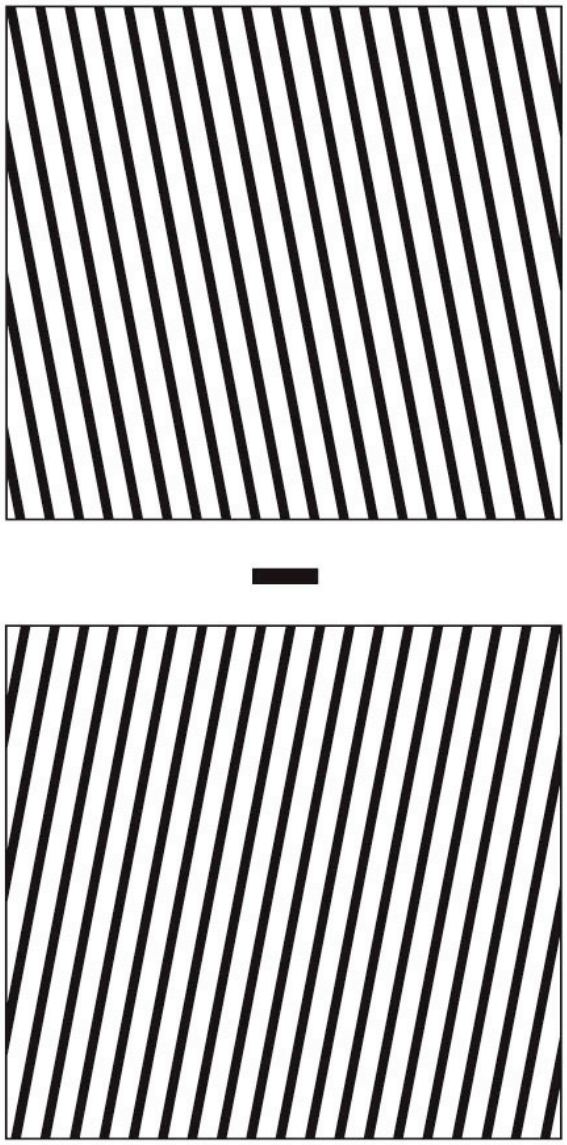
- adaptation

Chap 4:

- intro to object vision
- gestalt rules
- models & principles of object recognition

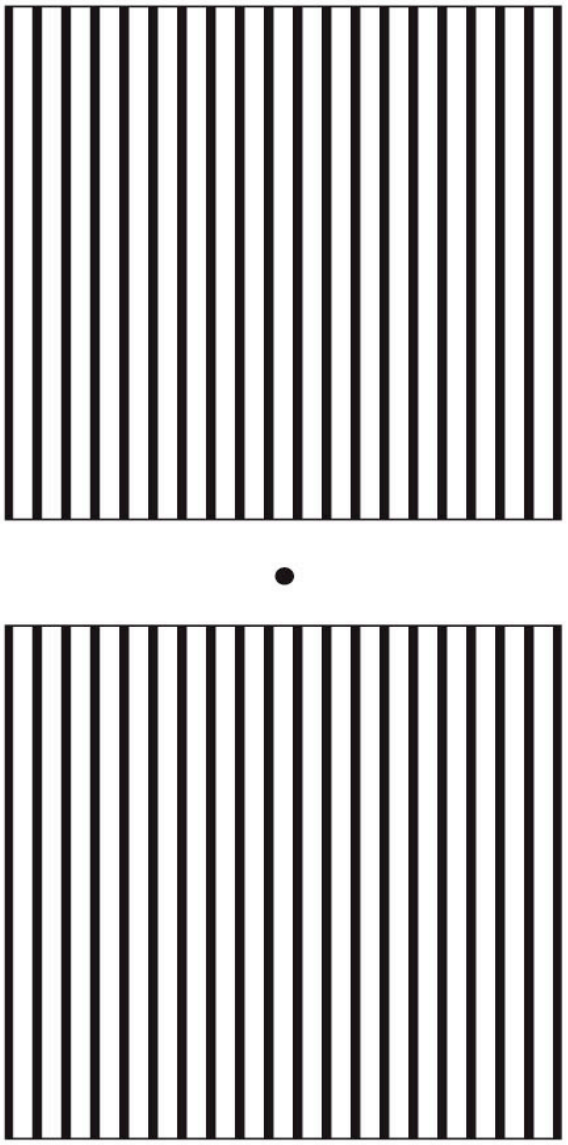
Adaptation

Adaptation: the Psychologist's Electrode



"tilt after-effect"

Adaptation: the Psychologist's Electrode



"tilt after-effect"

- perceptual illusion of tilt, provided by adapting to a pattern of a given orientation

- supports idea that the human visual system contains individual neurons selective for different orientations

Adaptation: the Psychologist's Electrode

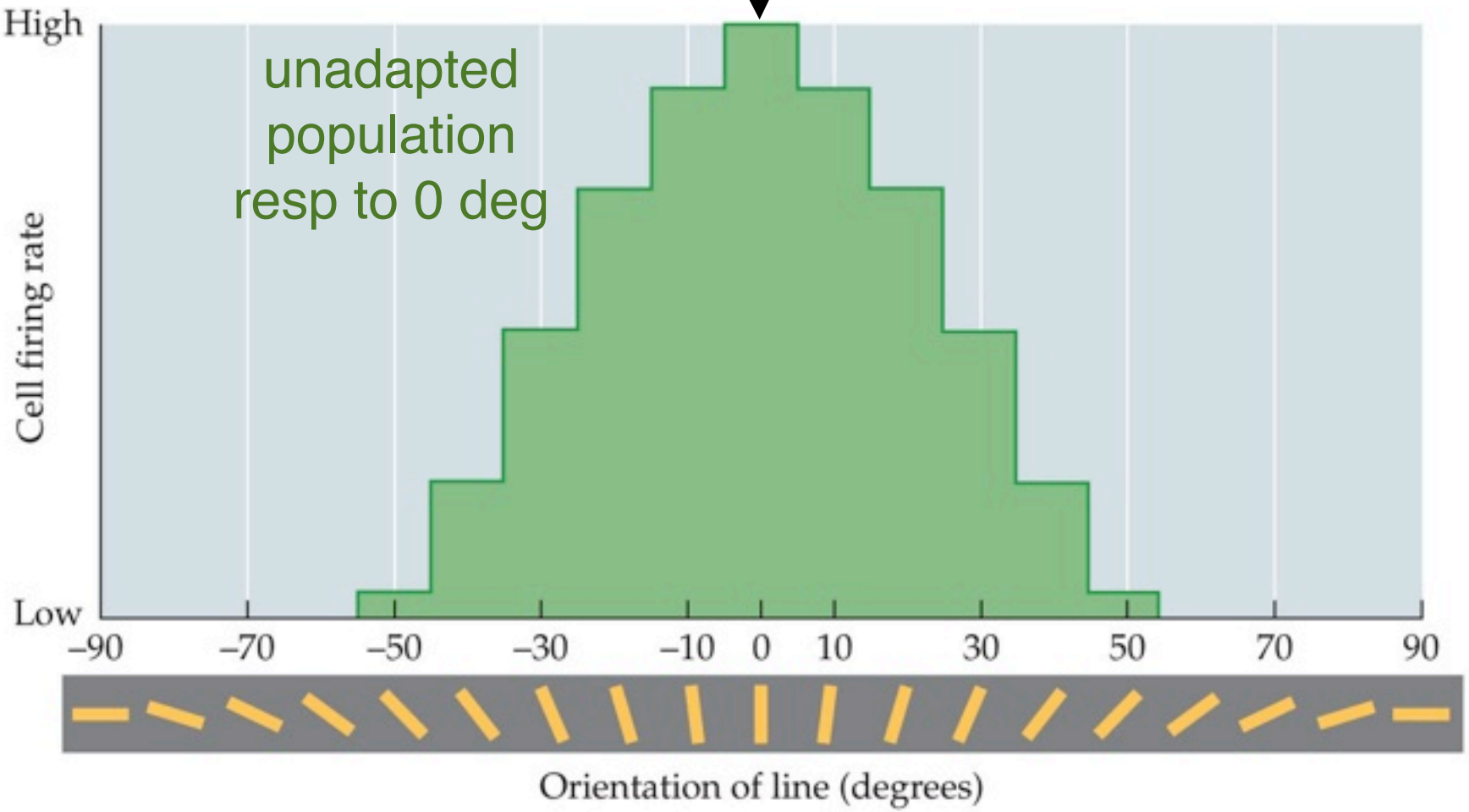
Adaptation: the diminishing response of a sense organ to a sustained stimulus

- An important method for deactivating groups of neurons without surgery
- Allows selective temporary "knock out" of group of neurons by activating them strongly

Effects of adaptation on population response and perception

Before Adaptation

0 degree stimulus

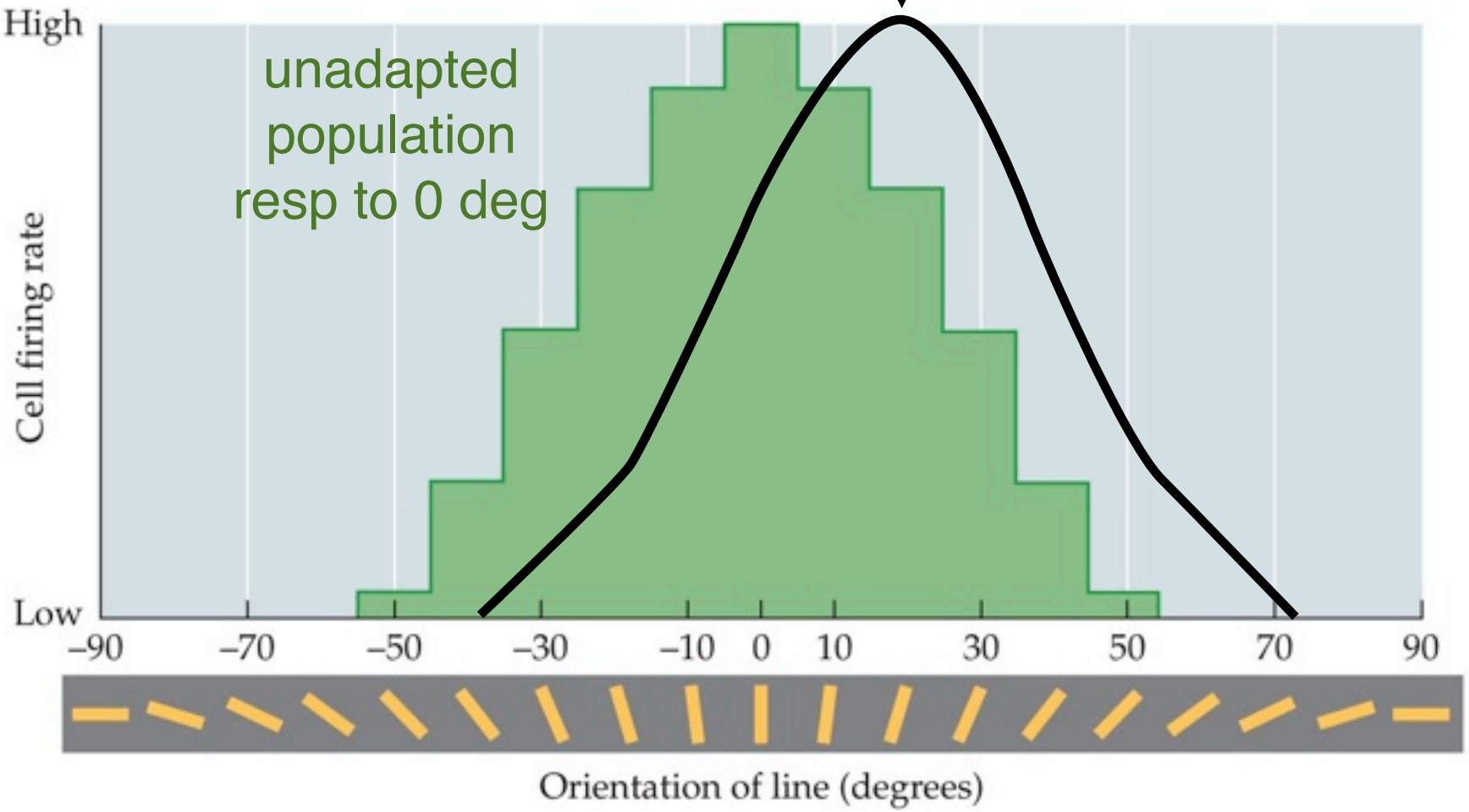


Stimulus presented =

Effects of adaptation on population response and perception

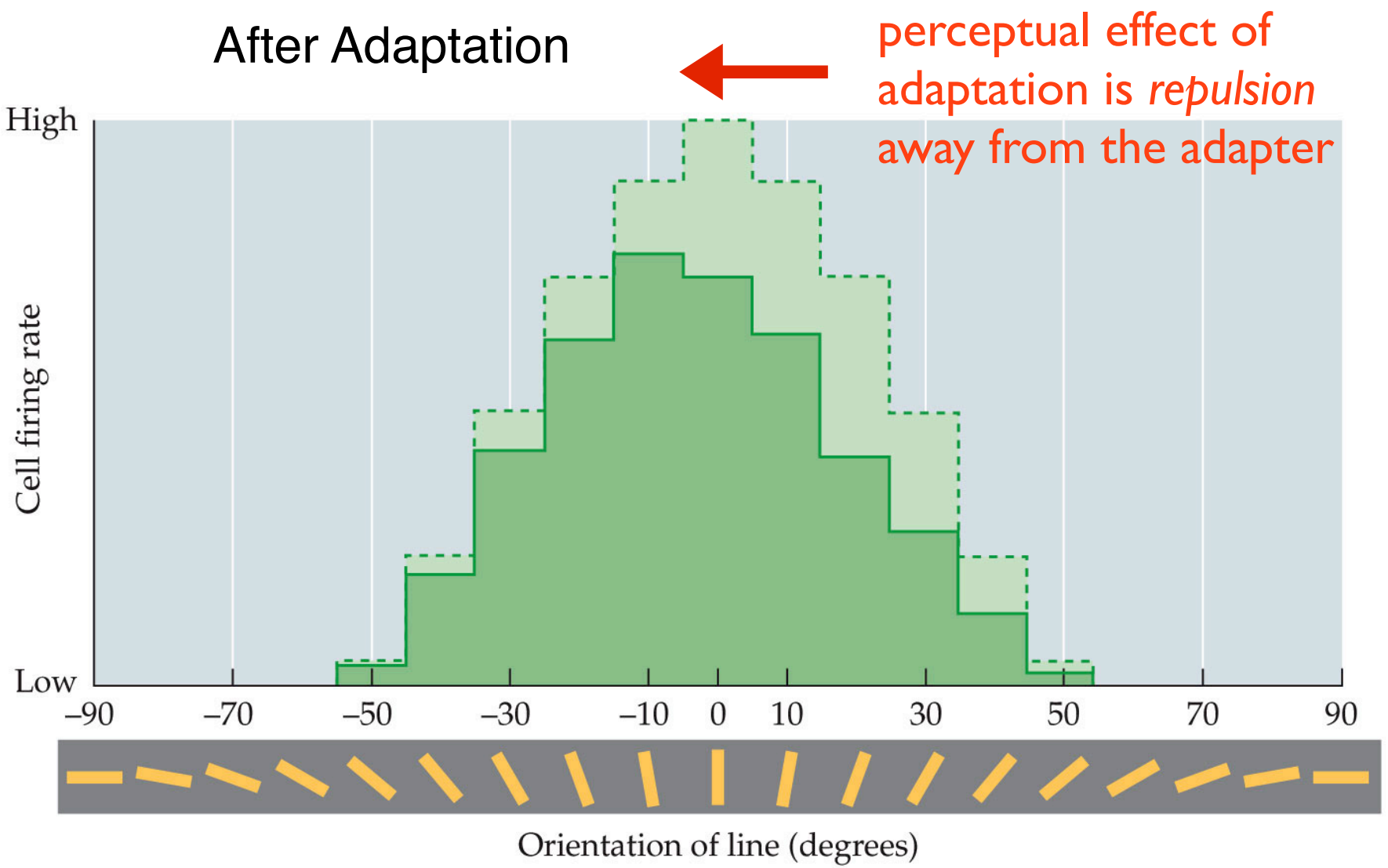
Before Adaptation

Then adapt to 20°



Stimulus presented = /

Selective adaptation alters neural responses and perception



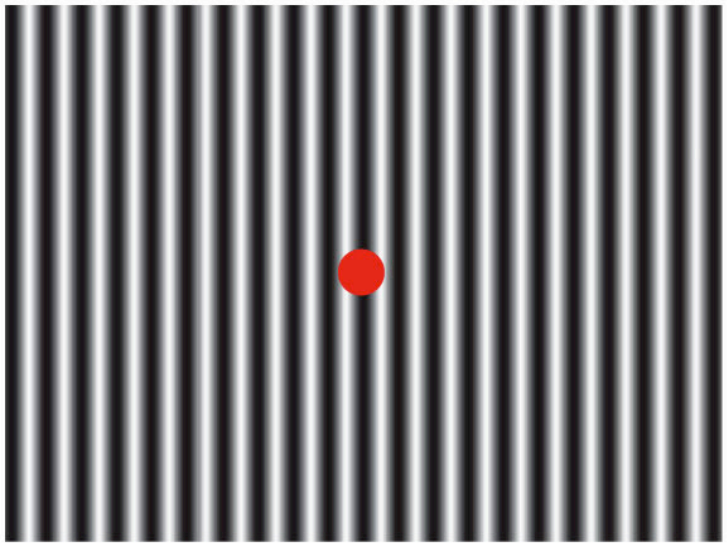
Stimulus presented =

Selective Adaptation: The Psychologist's Electrode

Selective adaptation for spatial frequency: Evidence that human visual system contains neurons selective for spatial frequency

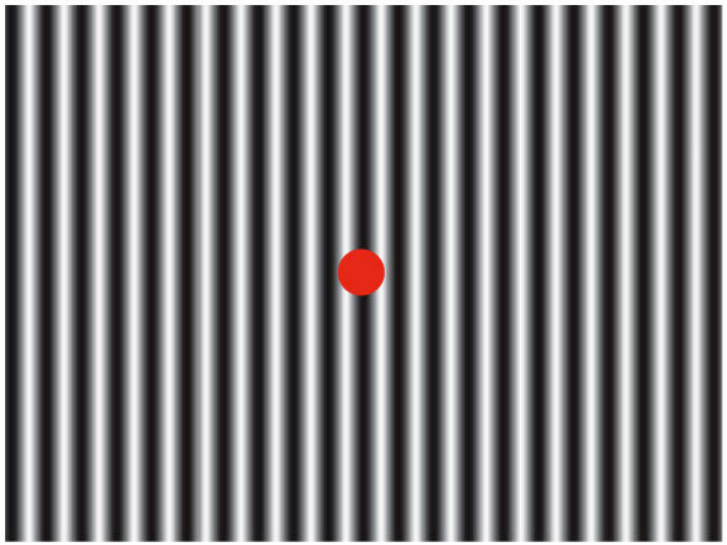
Adaptation that is specific to spatial frequency (SF)

1. adapt

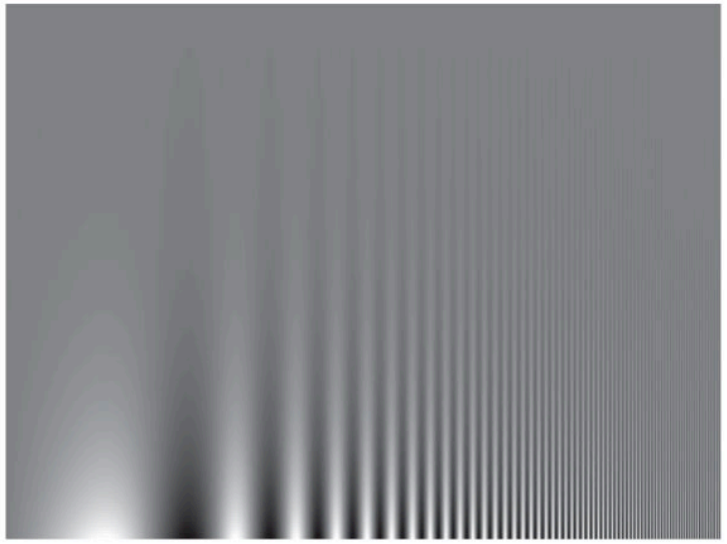


Adaptation that is specific to spatial frequency (SF)

1. adapt

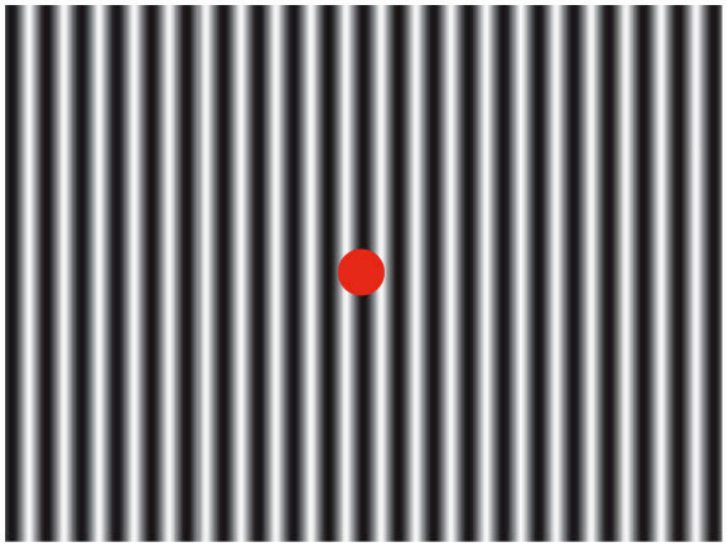


2. test

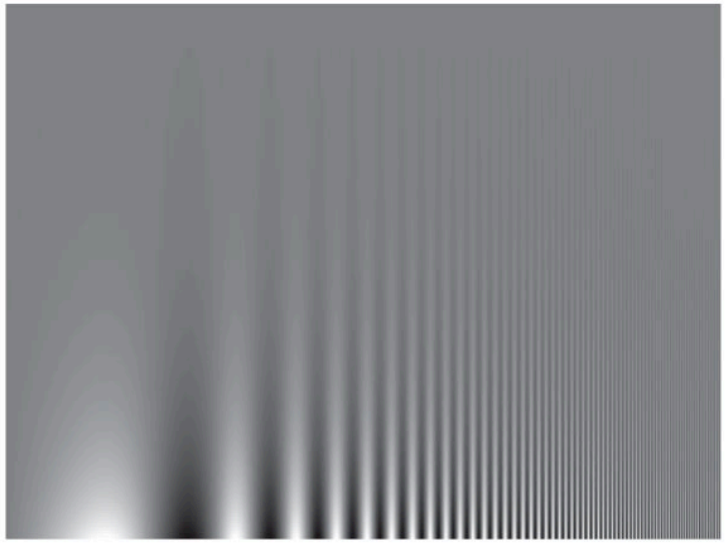


Adaptation that is specific to spatial frequency (SF)

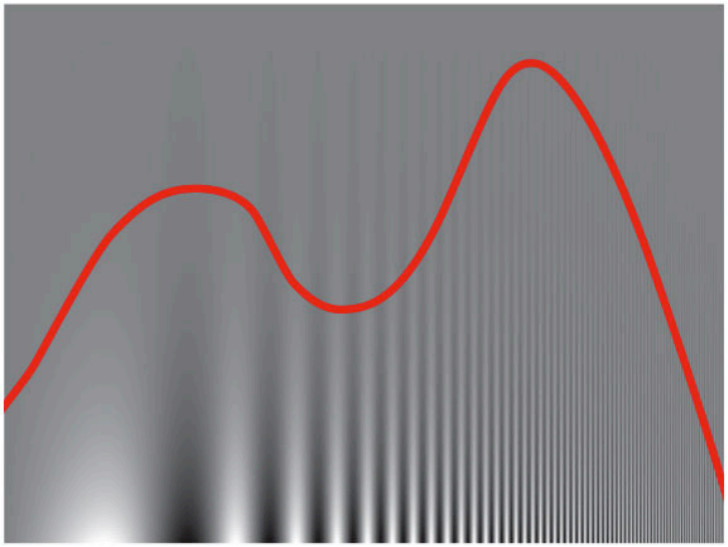
1. adapt



2. test

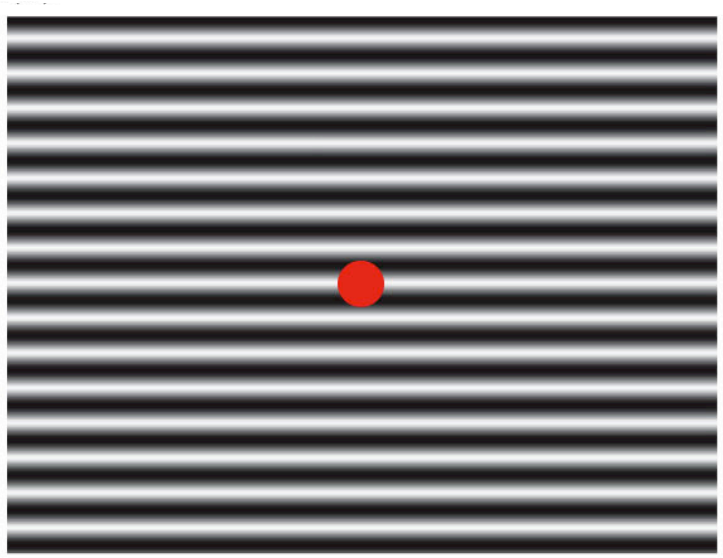


3. percept



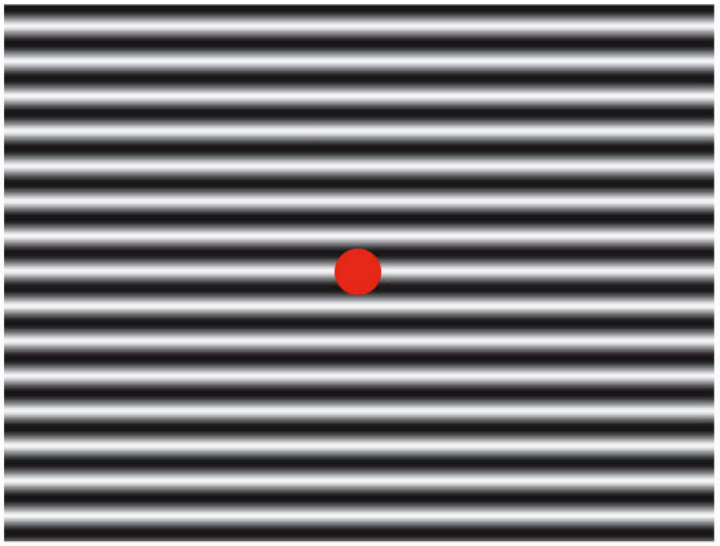
Adaptation that is specific to spatial frequency AND orientation

1. adapt

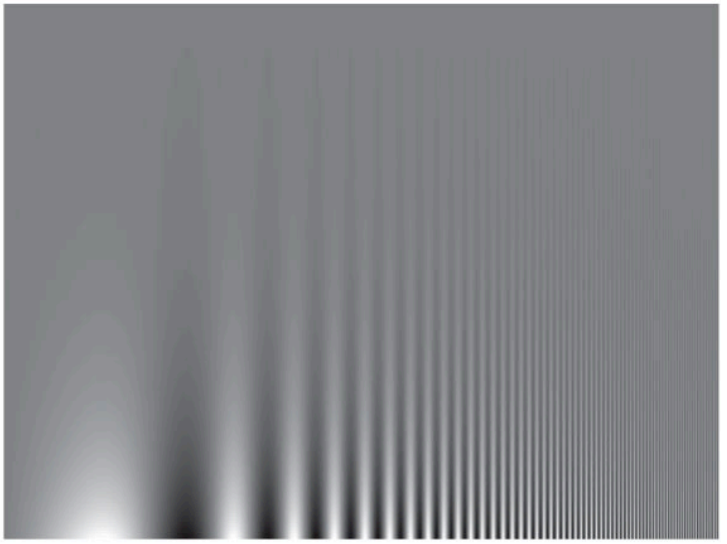


Adaptation that is specific to spatial frequency AND orientation

1. adapt

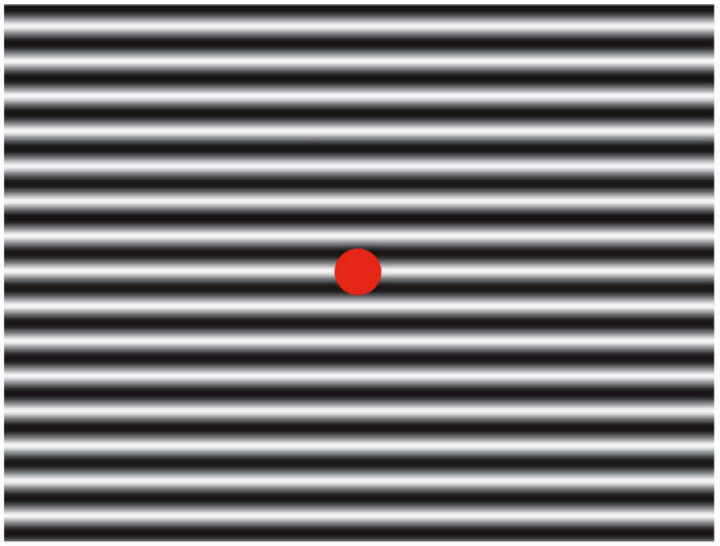


2. test

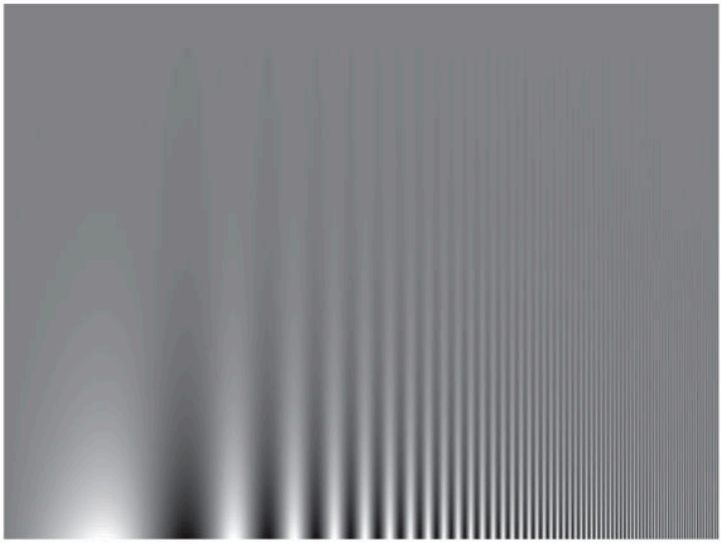


Adaptation that is specific to spatial frequency AND orientation

1. adapt

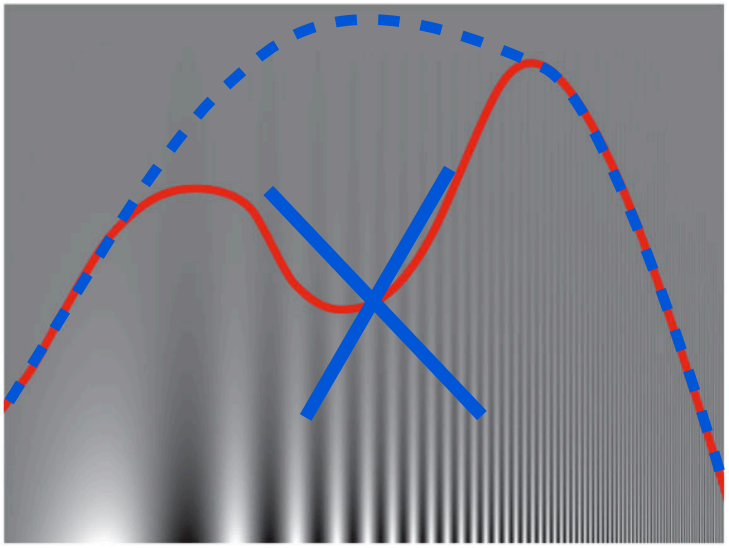


2. test



(c)

3. No adaptive percept



Selective Adaptation: The Psychologist's Electrode

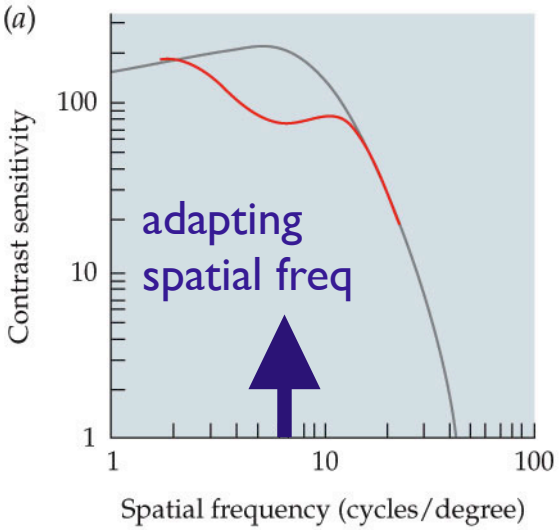
Orthodox viewpoint:

- If you can observe a particular type of adaptive after-effect, there is a certain neuron in the brain that is selective (or tuned) for that property

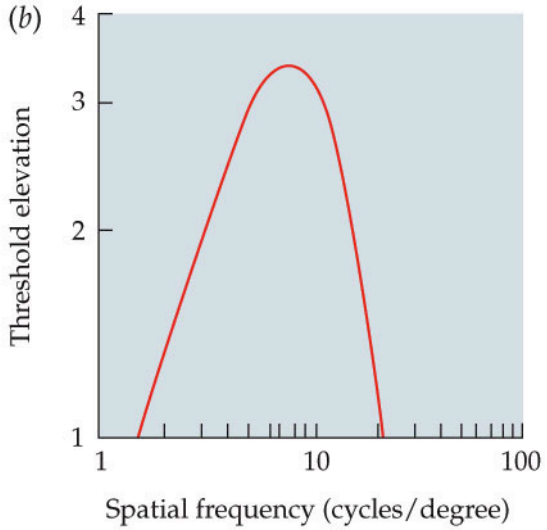
THUS (for example):

There are no neurons tuned for spatial frequency across all orientations, because adaptation is orientation specific.

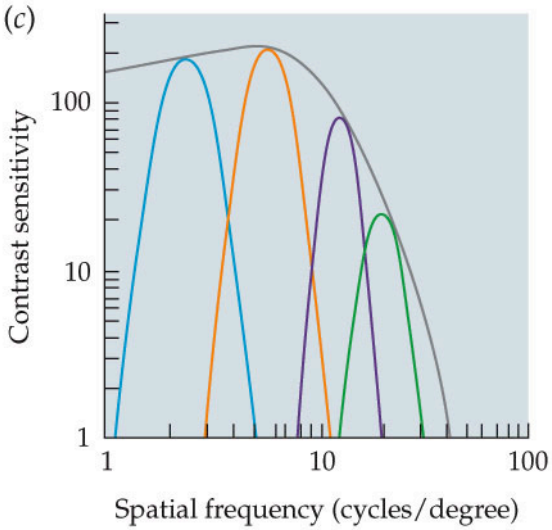
Selective Adaptation: The Psychologist's Electrode



contrast sensitivity *after* adaptation to a sine wave with a frequency of 7 cycles/degree.

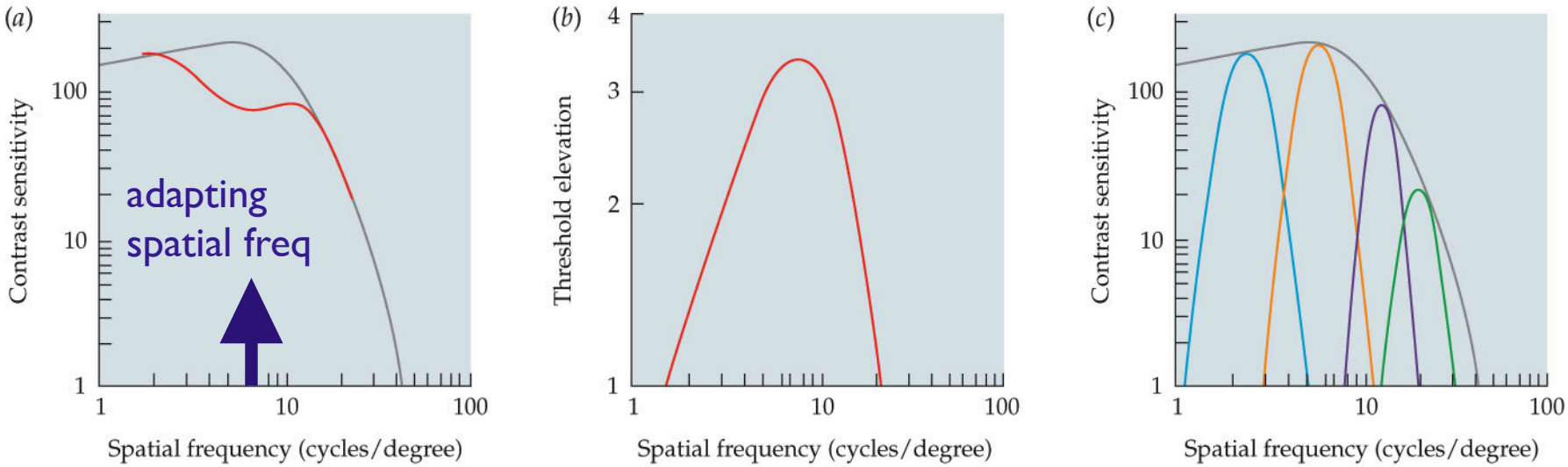


threshold increases near the adapted frequency



width of "channels" that contribute to contrast sensitivity

Selective Adaptation: The Psychologist's Electrode



Therefore:

- adaptation reveals separate channels devoted to orientation and spatial frequencies
- width of adaptive effect reveals the width of the channel

Summary (Chapter 3B)

- spatial frequency sensitivity & tuning
- V1 receptive fields, orientation tuning
- Hubel & Weisel experiments
- simple vs. complex cells
- cortical magnification
- cortical columns
- adaptation

4

Perceiving and Recognizing Objects

Introduction

What do you see?

Introduction

What do you see?

Introduction

What do you see?

Introduction

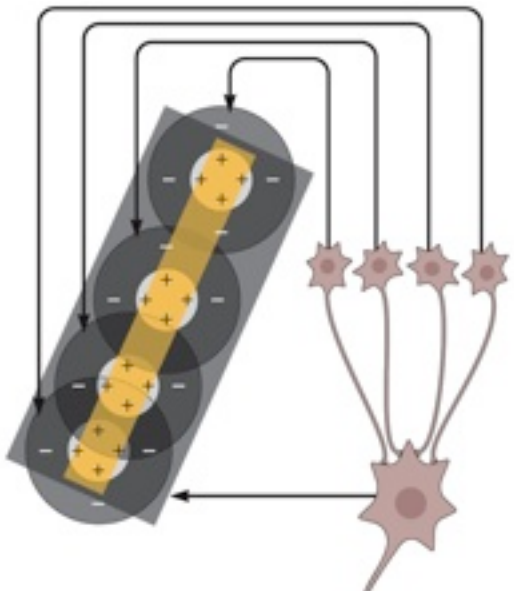
How did you recognize that all 3 images were of houses?

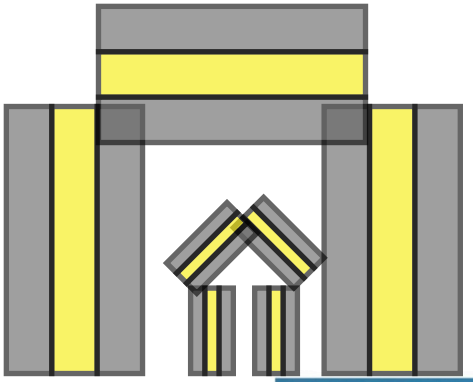
How did you know that the 1st and 3rd images showed the same house?

This is the problem of *object recognition*, which is solved in visual areas beyond V1.

Unfortunately, we still have no idea how to solve this problem.

Not easy to see how to make Receptive Fields for houses the way we combined LGN receptive fields to make V1 receptive fields!

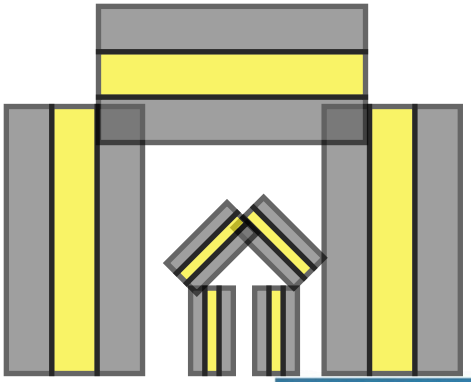




house-detector receptive field?

Ok for detecting a single "stick figure" house.

But this receptive field would never work: needs to recognize houses from different angles, sizes, colors, etc.



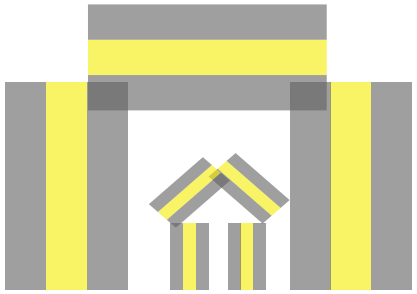
And how does it represent that it's the *same* house from different directions?

Viewpoint Dependence

View-dependent model - a model that will only recognize particular views of an object

- **template-based model**

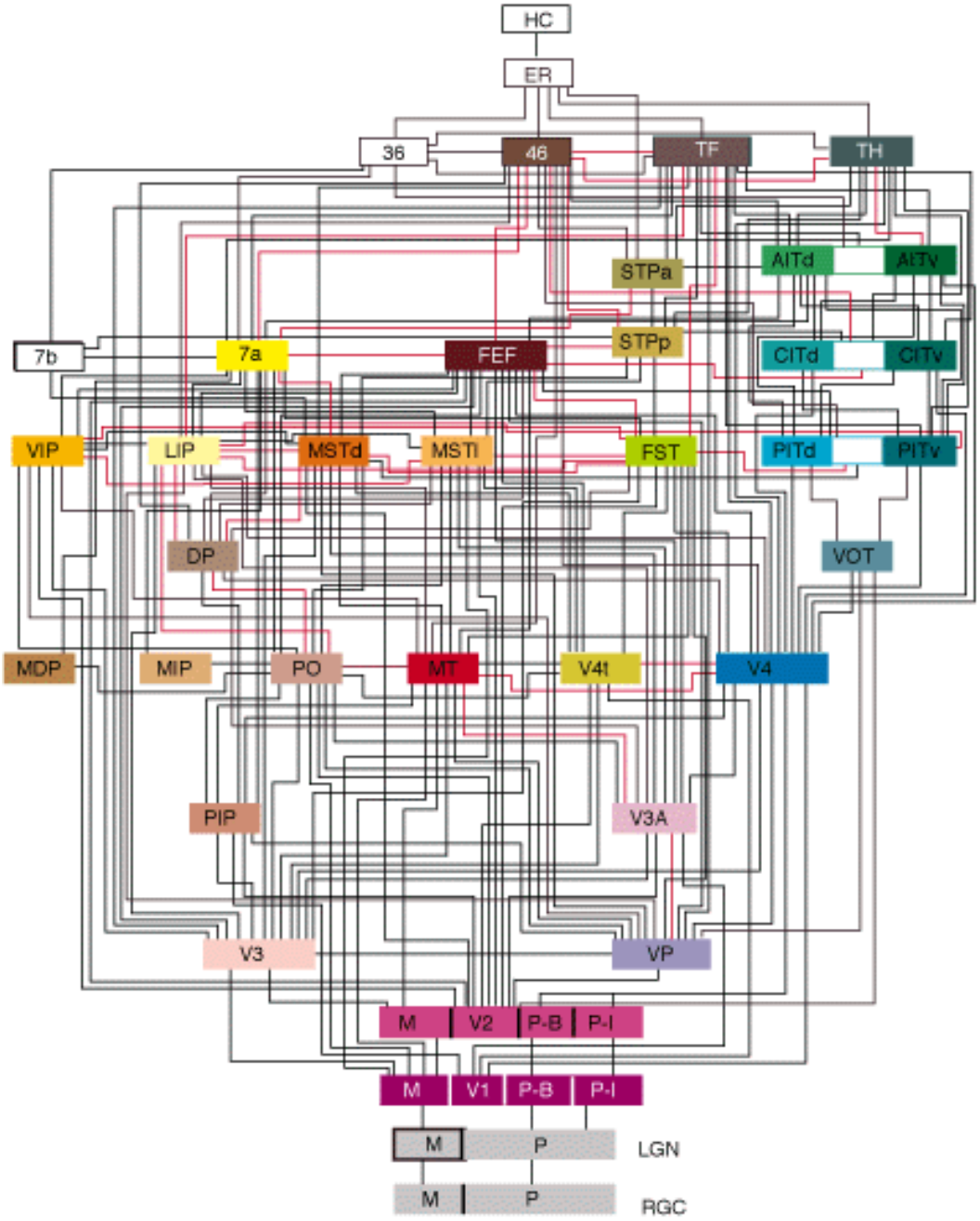
e.g.



"house" template

Problem: need a neuron (or "template") for every possible view of the object
- quickly run out of neurons!

Van Essen's Diagram of the Visual Pathway



not to scale!

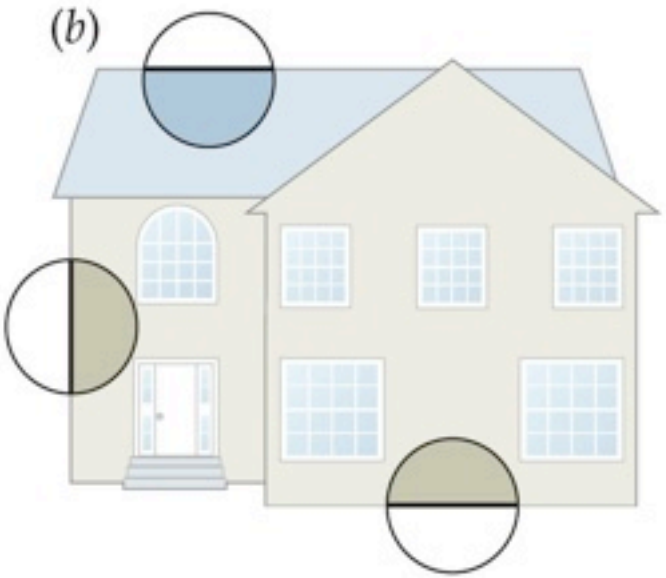
We still have (mostly) no idea what's going on here.

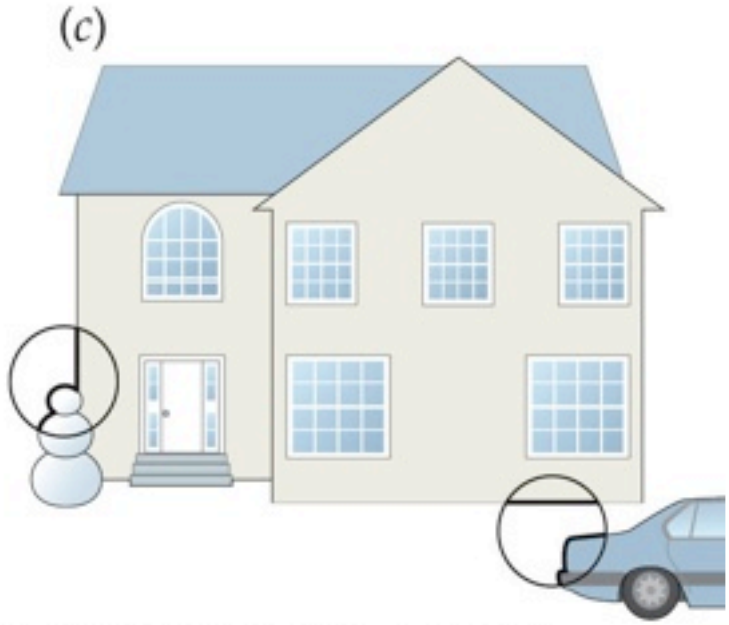
Middle Vision

Middle vision:

– *after* basic features have been extracted and *before* object recognition and scene understanding

- Involves perception of edges and surfaces
- Determines which regions of an image should be grouped together into objects





Finding edges

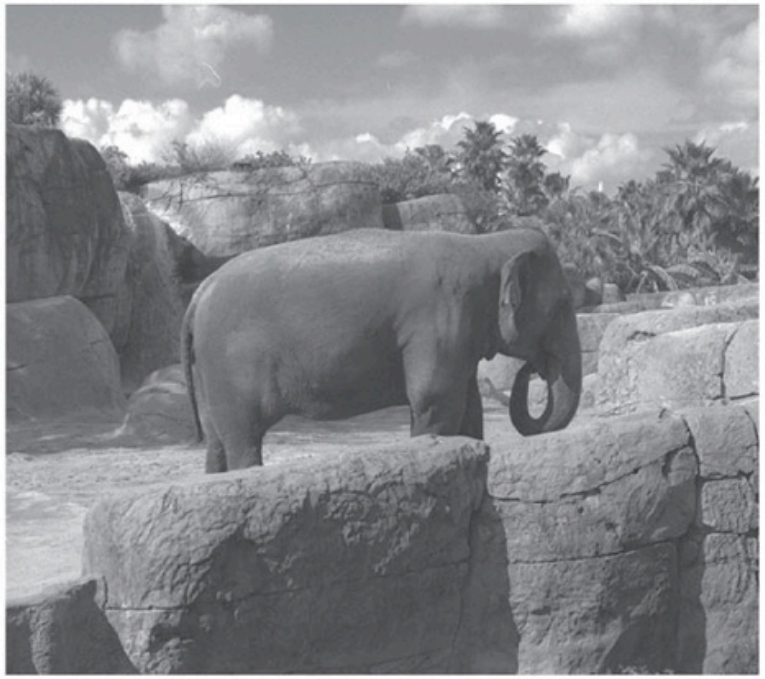
- How do you find the edges of objects?
- Cells in primary visual cortex have small receptive fields
- How do you know which edges go together and which ones don't?

Middle Vision

Computer-based edge detectors are not as good as humans

- Sometimes computers find too many edges

(b)



(c)

- "Edge detection" is another theory (along with Fourier analysis!) of what V1 does.

Middle Vision

Computer-based edge detectors are not as good as humans

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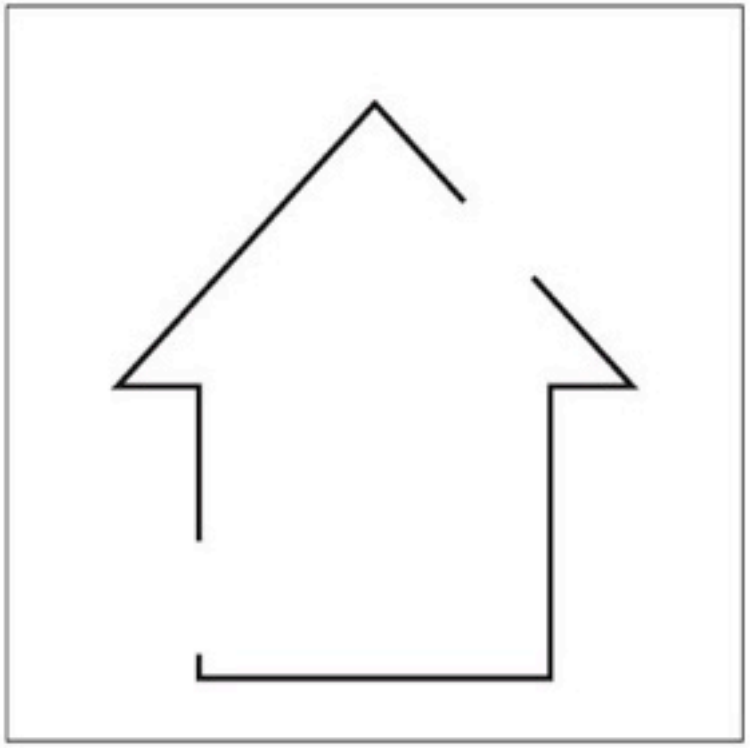
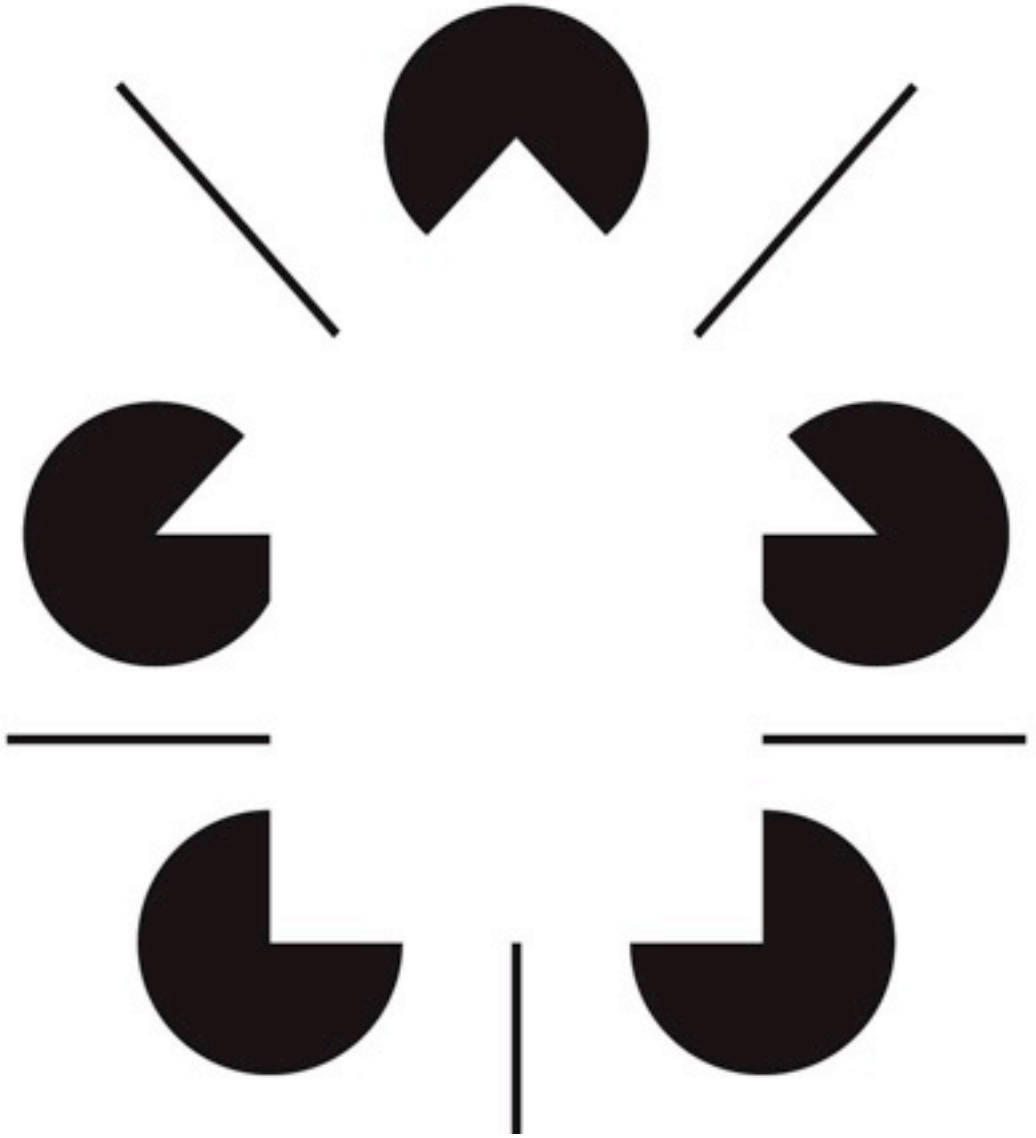


Figure 4.5 This “house” outline is constructed from illusory contours

“Kanizsa Figure”

illusory contour: a contour that is perceived even though nothing changes from one side of the contour to the other in the image



Gestalt Principles

- **Gestalt**: In German, “form” or “whole”
- **Gestalt psychology**: “The whole is greater than the sum of its parts.”
- Opposed to other schools of thought (e.g., structuralism) that emphasize the basic elements of perception

structuralists:

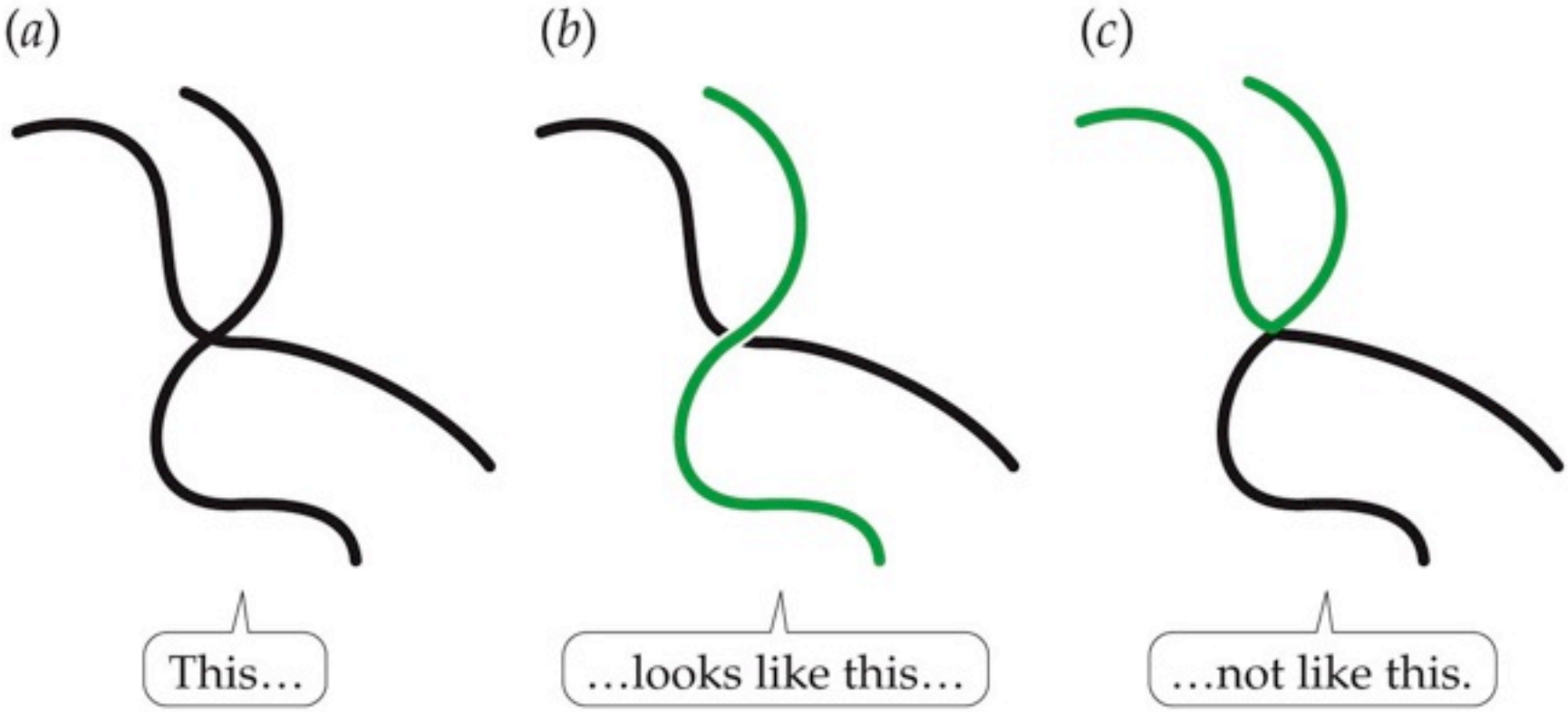
- perception is built up from “atoms” of sensation (color, orientation)
- challenged by cases where perception seems to go beyond the information available (eg, illusory contours)

Gestalt grouping rules:

a set of rules that describe when elements in an image will appear to group together

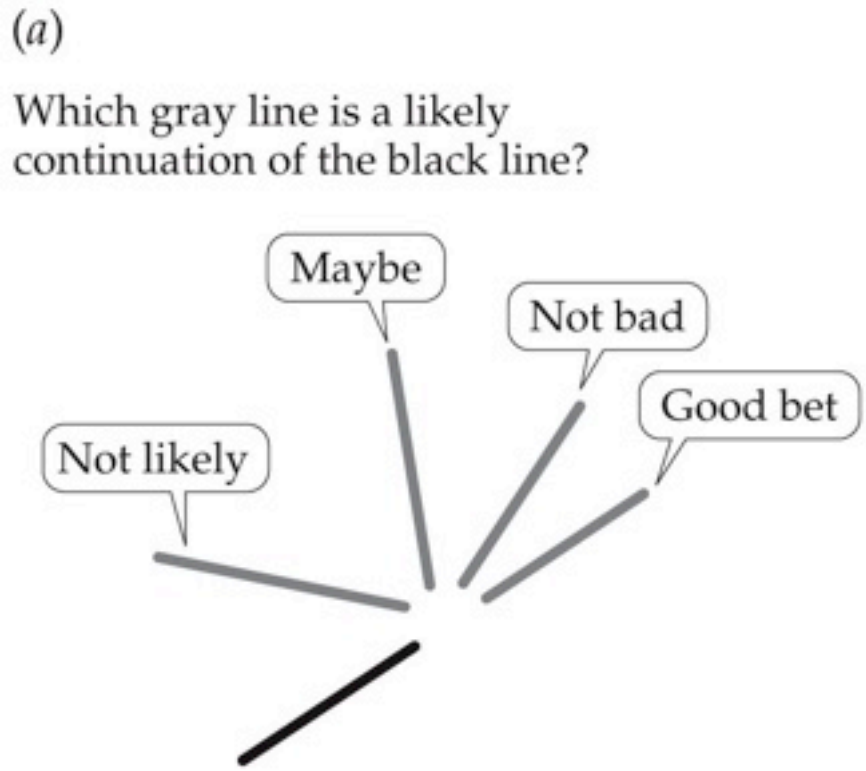
Gestalt Principles

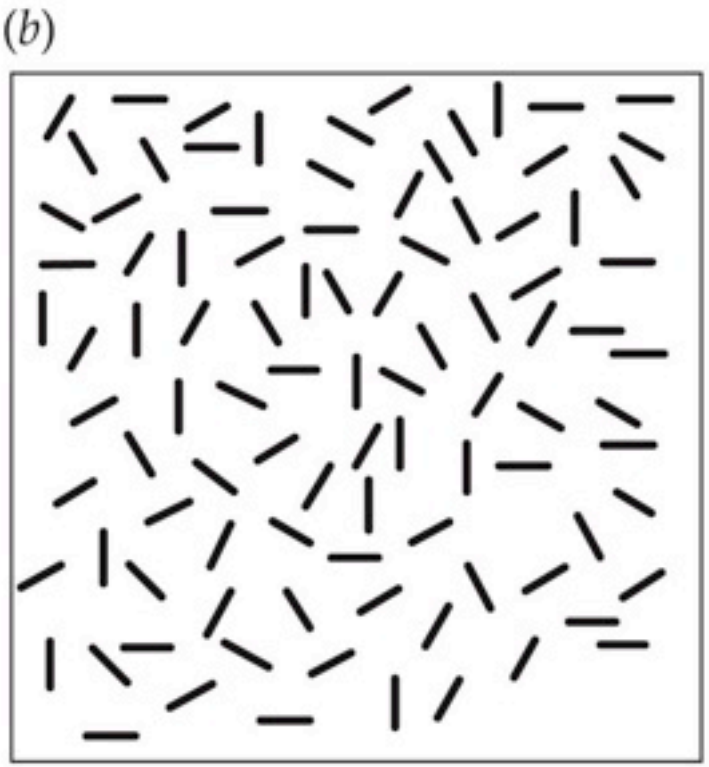
Good continuation: A Gestalt grouping rule stating that two elements will tend to group together if they lie on the same contour



Gestalt Principles

Good continuation: A Gestalt grouping rule stating that two elements will tend to group together if they lie on the same contour

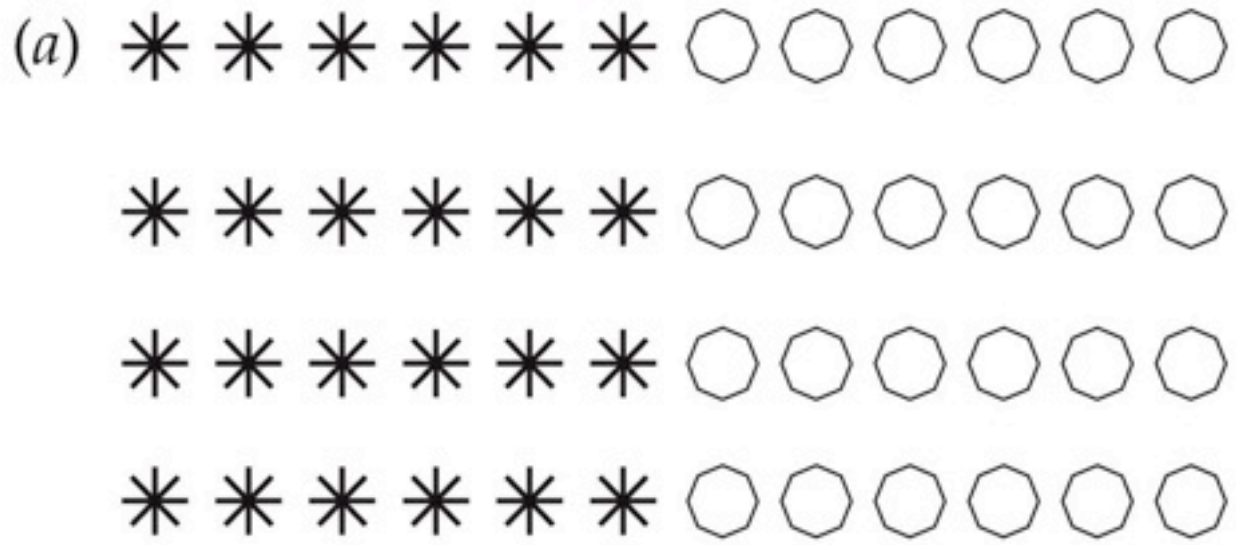




Gestalt Principles

Gestalt grouping principles:

- **Similarity**
- **Proximity**



Gestalt Principles

Dynamic grouping principles

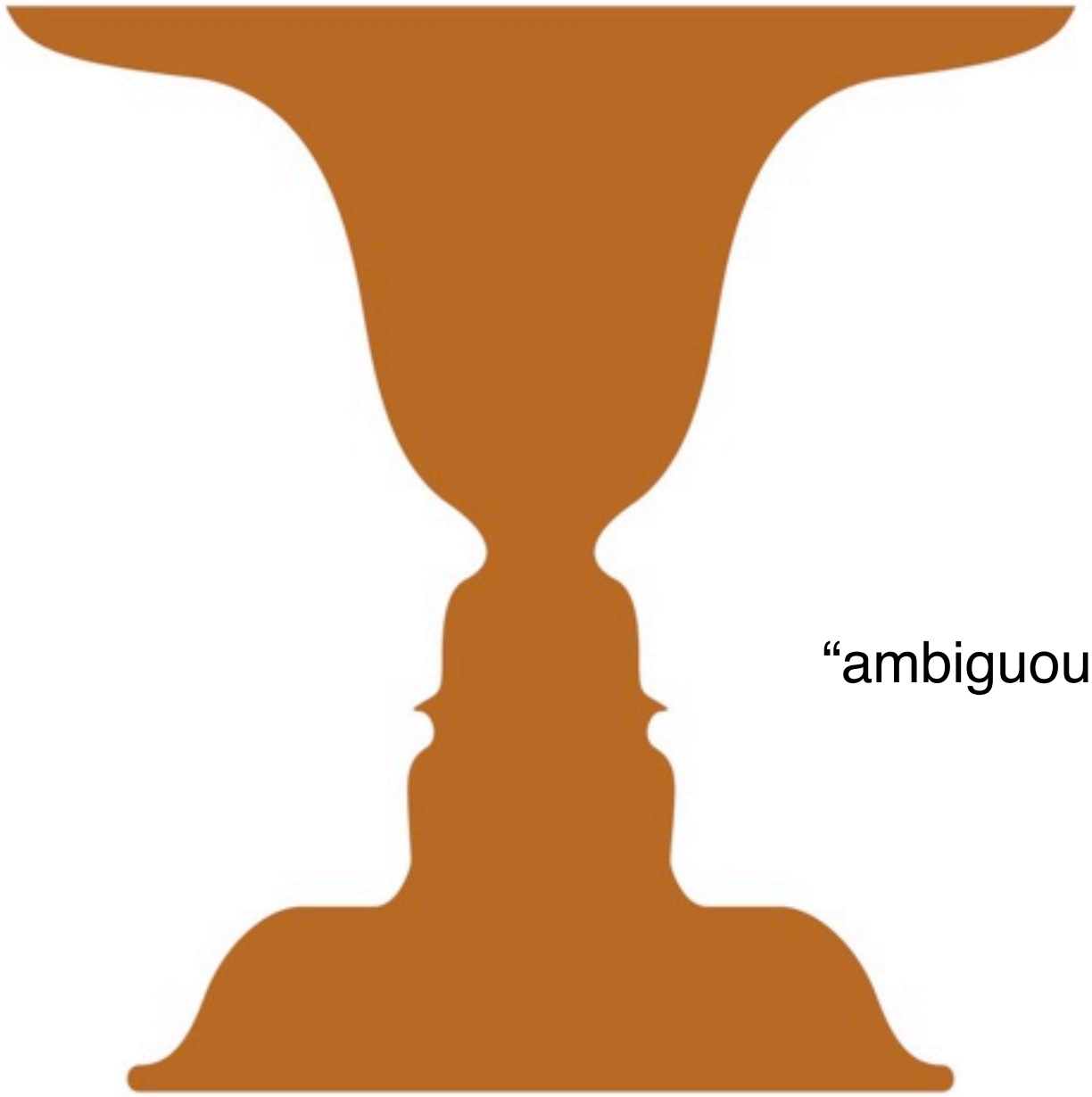
- **Common fate**: Elements that move in the same direction tend to group together

- **Synchrony**: Elements that change at the same time tend to group together

(See online demonstration: book website)

http://sites.sinauer.com/wolfe4e/wa04.01.html

Figure/Ground Segregation: Face/Vase Illusion

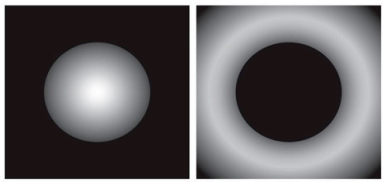


"ambiguous figure"

Gestalt Principles

Gestalt figure–ground assignment principles:

- **Surroundedness**: The surrounding region is likely to be ground
- **Size**: The smaller region is likely to be figure
- **Symmetry**: A symmetrical region tends to be seen as figure
- **Parallelism**: Regions with parallel contours tend to be seen as figure
- **Extremal edges:** If edges of an object are shaded such that they seem to recede in the distance, they tend to be seen as figure

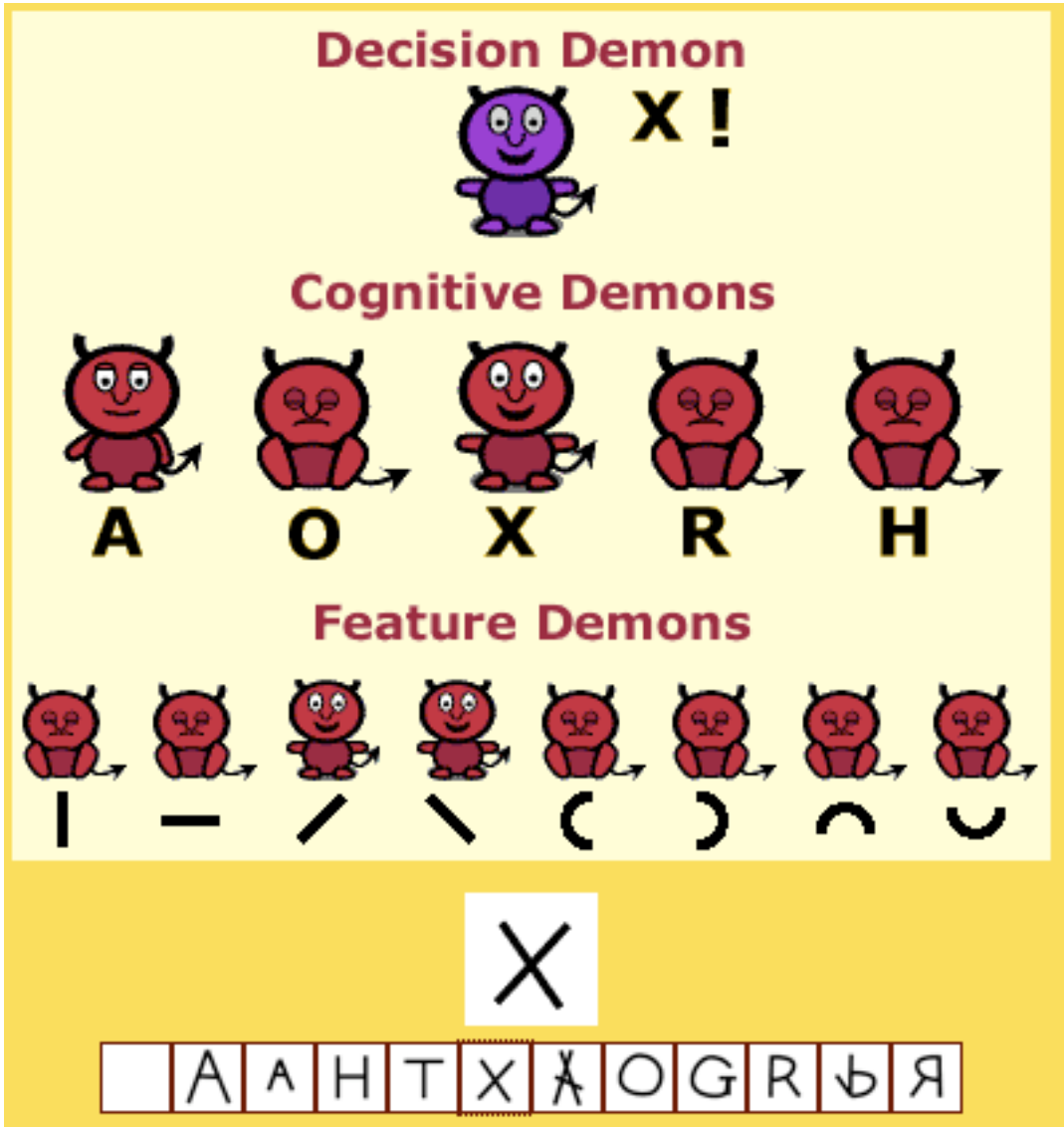


Models of Object Recognition

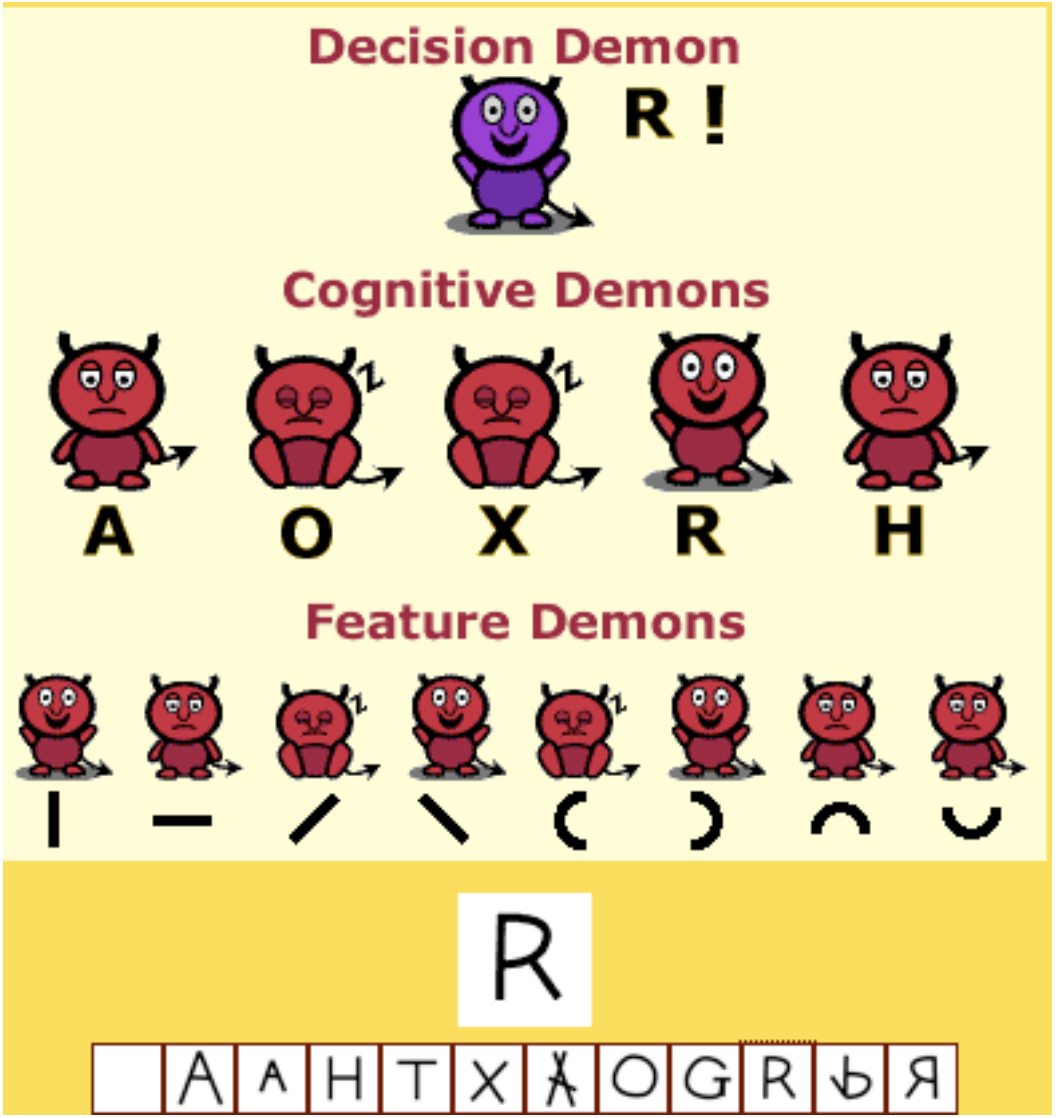
pandemonium model

- Oliver Selfridge's (1959) simple model of letter recognition
- Perceptual committee made up of "demons"
    - Demons loosely represent neurons
    - Each level is a different brain area
- Pandemonium simulation: http://sites.sinauer.com/wolfe4e/wa04.02.html

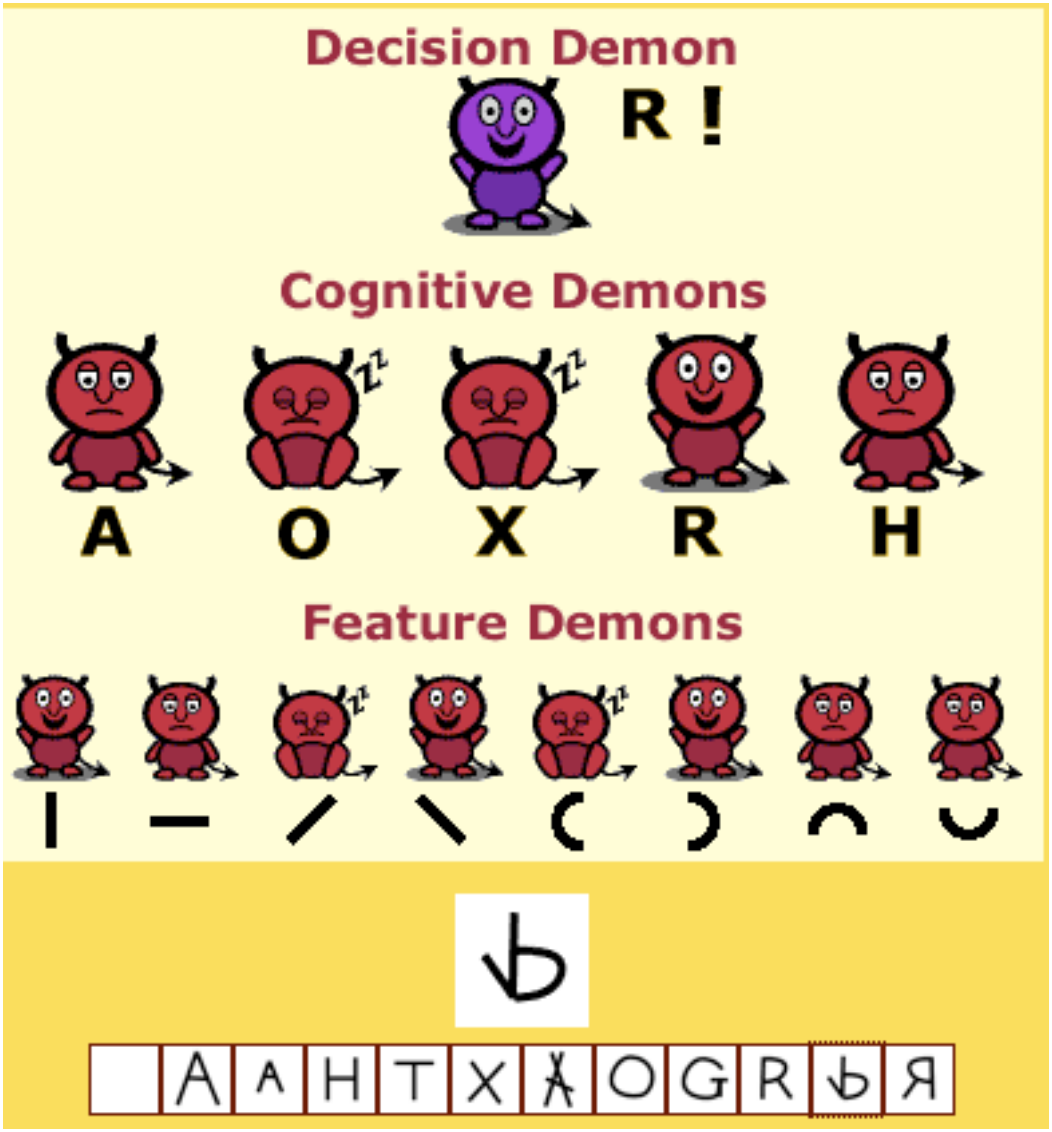
Models of Object Recognition



Models of Object Recognition



Models of Object Recognition



Models of Object Recognition

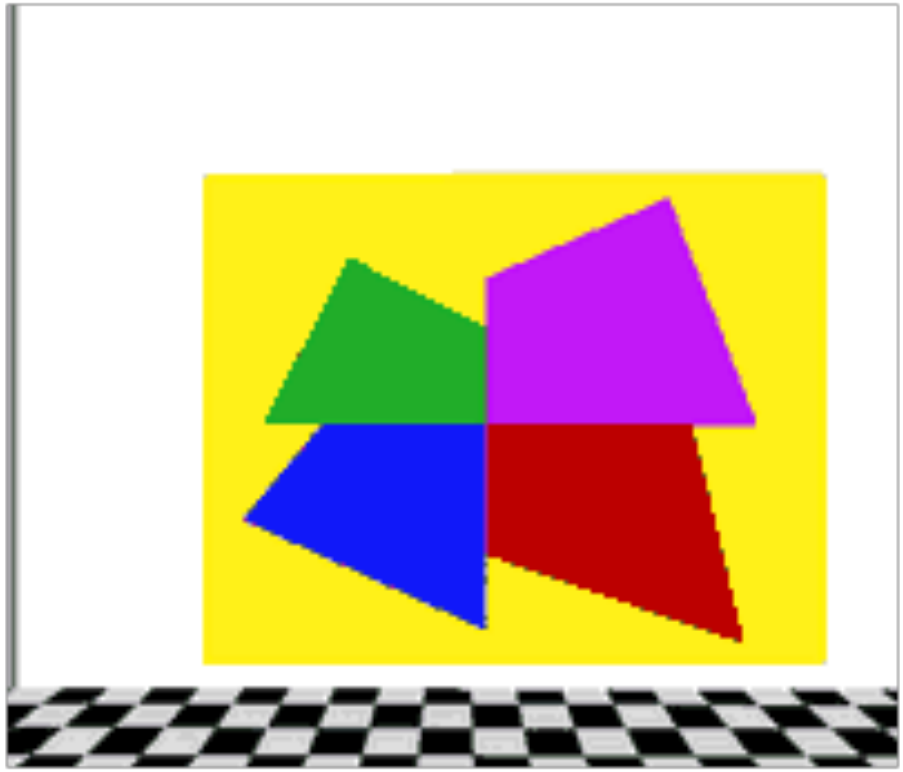
- Hierarchical "constructive" models of perception:
- Explicit description of how parts are combined to form representation of a whole

Metaphor: "committees" forming consensus from a group of specialized members

• perception results from the consensus that emerges

Accidental Viewpoints

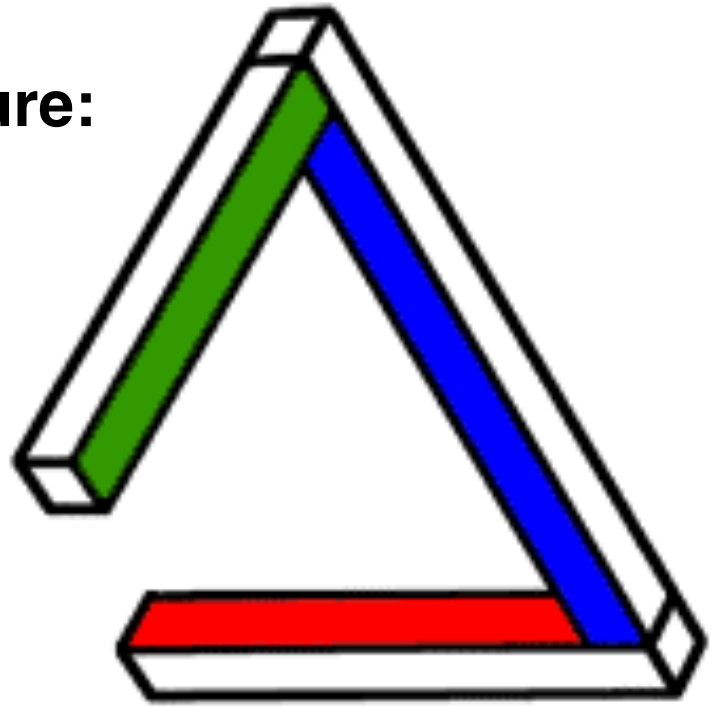
- **Accidental viewpoint:** produces some regularity in the visual image that is not present in the world
- Perceptual system will not adopt interpretations that assume an accidental viewpoint.



Accidental Viewpoints

- **Accidental viewpoint:** produces some regularity in the visual image that is not present in the world
- Perceptual system will not adopt interpretations that assume an accidental viewpoint.

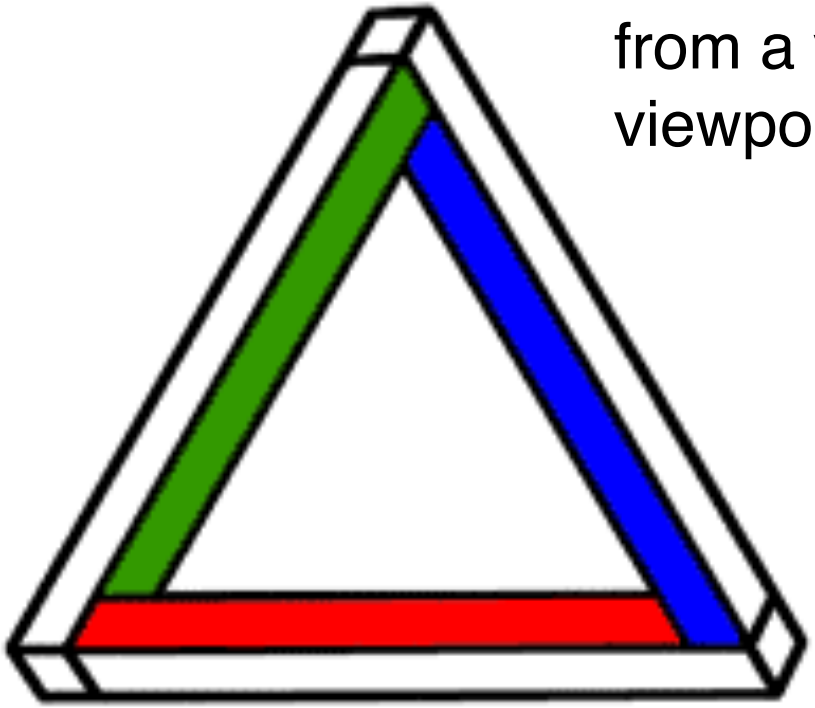
- **Belivable 3-d figure:**



Accidental Viewpoints

- **Unbelievable figure**

You could build a 3D object that would lead to this 2D image, but would need to take the picture from a very specific viewpoint



(Another example of an “ambiguous figure”)

Impossible triangle
(Perth, Australia)

Impossible triangle
(Perth, Australia)

Accidental Viewpoints in art

Accidental Viewpoints in art

Accidental Viewpoints in art

Accidental Viewpoints in art

Accidental Viewpoints in art