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

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

Actual receptive fields do not have “cookie-cutter” shapes:

The receptive field profiles of orientationally-selective simple cells in V1 are often fit well by Gabor functions.
Complex cells are orientation selective. They
- combine inputs from several neighboring simple cells
- are \textit{insensitive} to the position of a bar in the receptive field
- respond \textit{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

Angle detectors

Bar detectors

Visual stimulation
Feature Nets

Square detector

Angle detectors

Bar detectors

Bottom-up or Data-driven

Visual stimulation
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)

Optical Character Recognition (OCR)
Bottom-up processing in visual word recognition
Top-down processing

TAE CAT
Top-down processing

context affects what is perceived
(A) Top-down processing

Formulate hypothesis about the identity of the stimulus.

Thoughts about *animal*

MAT → CAT → RAT

Select and examine relevant aspects of the stimulus to check the hypothesis.

(B) Bottom-up processing

Combine features into more complex forms.

MAT → CAT → RAT

Detect features of the input.

MAT → CAT → RAT

Psychology, 8/e  Figure 5.15
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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

![Triangles](image)
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.

0 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.

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

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
- Interposition
Gestalt Laws of Perceptual Organization

- Proximity
- Similarity
- Closure

Good continuation:
- Continue an edge in a way that minimizes change in direction.

No

Yes

T. M. D’Zmura
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*

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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

**A. Similarity**
We tend to group these dots into columns rather than rows, grouping dots of similar colors.

**B. Proximity**
We tend to perceive groups, linking dots that are close together.

**C. Good continuation**
We tend to see a continuous green bar rather than two smaller rectangles.

**D. Closure**
We tend to perceive an intact triangle, reflecting our bias toward perceiving closed figures rather than incomplete ones.

**E. Simplicity**
We tend to interpret a form in the simplest way possible. We would see the form on the left as two intersecting rectangles (as shown on right) rather than as a single 12-sided irregular polygon.

*Psychology, 8/e* Figure 5.8
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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